LAGUNAS PERÚ MAY 26, 2019 EARTHQUAKE

VIRTUAL ASSESSMENT STRUCTURAL TEAM (VAST) REPORT

Earthquake damage in Santa Cruz, Alto Amazonas Province, Perú on May 26, 2019. (Source: Rotafono [2])

VAST Authors	VAST Editors
Lead Author: Eduardo Miranda, Stanford University **Co-Authors** (in alphabetical order) Andrés Acosta, Stanford University Luis Ceferino, Stanford University Héctor Dávalos, Universidad Panamericana, México Francisco Galvis, Stanford University Selim Gunay, University of California, Berkeley Pablo Heresi, Stanford University Jorge Macedo, Georgia Institute of Technology Sebastián Miranda, PUC, Chile José M. Ramos, Universidad Michoacana San Nicolás Hidalgo, México Pedro Rojas, ESPOL and UCSG, Ecuador Jorge Ruiz-García, Universidad Michoacana San Nicolás Hidalgo, México Xavier Vera, GeoEstudios and UCSG, Ecuador	(in alphabetical order) Khalid M. Mosalam, University of California, Berkeley Ian N. Robertson University of Hawaii David Roueche Auburn University

Released: June 3, 2019 | **NHERI DesignSafe Project ID:** PRJ-2395

Table of Contents

1. Executive Summary

On Sunday May 26, 2019, a magnitude (M_w) 8.0 earthquake took place in Eastern Perú. The earthquake occurred at 2:41 am local time and was caused by an intermediate-depth normal fault rupture on the Nazca plate at a depth of approximately 110 km. According to official communications, available as of May 30th, the earthquake resulted in 2 fatalities, 17 injuries, one collapsed bridge, 5 affected pedestrian bridges, multiple landslides, affected roads (about 51km of affected roads), and damage to hundreds of structures including: 46 health centers, 296 school buildings, 15 commercial buildings, 15 churches, including 5 collapses, and more than 600 uninhabitable residential units (COEN, Perú 2019b).

The combination of the earthquake happening in a sparsely populated area in the back-arc region (east side of the Andes), which is mainly a tropical forest region in the country, and being a relatively deep event led to relatively small amount of damage considering the large magnitude of the event.

For the community of earthquake engineering researchers and practitioners, the multidisciplinary reconnaissance information available right after the event provides an important opportunity to learn from this earthquake, both technically and also from a policy and decision making perspective. As such, this report gathers some publicly-available information, by (i) providing a summary of the origin of the event and its main seismological features, (ii); presenting a summary of ground motions recorded in two countries; and (iii) summarizing the preliminary reports of damage. This **Virtual Assessment Structural Team (VAST) Report** is a product of StEER to support those seeking to learn from this seismic event and to inform possible future Field Assessment Structural Teams (FAST).

2. Introduction

On Sunday May 26, 2019, an Mw 8.0 earthquake took place in Eastern Perú. The earthquake occurred as the result of an intermediate-depth normal faulting rupture of the Nazca plate. Focal mechanism solutions provided by the U.S. Geological Survey (USGS) indicate that the rupture occurred on either a north- or south-striking, moderately dipping normal fault. Perú is located within the subduction zone of the Nazca plate which subducts in an eastern downward motion relative to the South America plate at a velocity of approximately 7 cm/yr (about 2.7 inch/yr). Intermediate-depth subduction events are relatively common in northern Perú and western South America. They typically cause less damage on the ground surface above their foci than similar-magnitude shallow-focus earthquakes, but large intermediate-depth earthquakes may be felt at great distance from their epicenters (USGS, 2019).

The initial product of the StEER response to the 2019 Lagunas Perú Earthquake is this **Virtual Assessment Structural Team (VAST) report**, which is intended to:

1. Provide an overview of the tectonic characteristics of the event;
2. Summarize ground motions recorded in two countries;
3. Summarize preliminary reports of damage to wide-ranging of structures and infrastructure

It should be emphasized that all information contained herein is preliminary and based on the rapid assessment of publicly available online data within 4 days of the event.

3. Earthquake Details and Tectonic Summary

On Sunday May 26, 2019, at 7:41:14 UTC (2:41:14 local time), a magnitude (M_w) 8.0 earthquake took place in Eastern Perú approximately 720 km northeast of Lima (Figure 3.1). The earthquake occurred as the result of an intermediate-depth normal faulting rupture of the Nazca plate. The hypocenter of the earthquake was located at 5.796°S 75.298°W at a depth of 109.9 km (USGS, 2019). Focal mechanism solutions provided by the U.S. Geological Survey (USGS) indicate that the rupture occurred on either a north- or south-striking, moderately dipping normal fault. Perú is located within the subduction zone of the Nazca plate which subducts in an eastern downward motion relative to the South America plate in this region at a velocity of approximately 7 cm/yr (about 2.7 inch/yr). Intermediate-depth subduction events are relatively common in northern Perú and western South America. They typically cause less damage on the ground surface above their foci than similar-magnitude shallow-focus earthquakes, but large intermediate-depth earthquakes may be felt at great distance from their epicenters (USGS, 2019). The earthquake was felt by people in Perú, Ecuador, Colombia, Venezuela and Brazil.

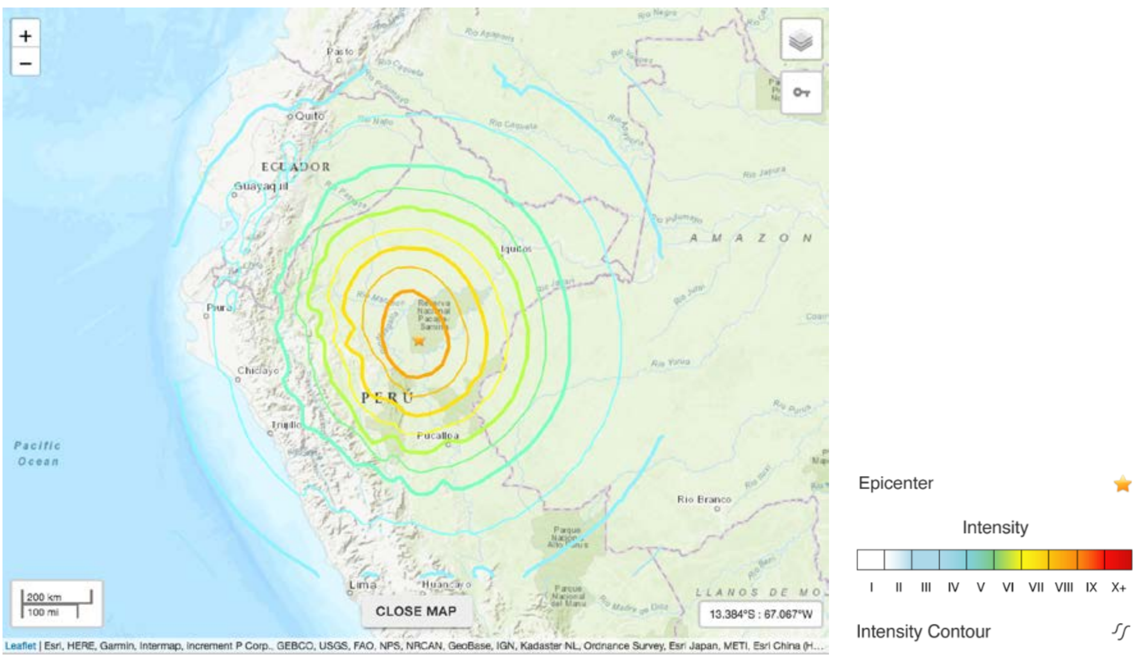


Figure 3.1. USGS interactive intensity map for the 2019 M 8.0 Lagunas earthquake (USGS, 2019).

3.1 Tectonic setting

Large magnitude earthquakes in South America are produced as a result of the relative motion occurring between the subducting Nazca plate and the South America plate, where the oceanic crust and lithosphere of the Nazca plate begin their descent into the mantle beneath South America. The convergence associated with this subduction process is responsible for the uplift of the Andes Mountains and for the active volcanic chain present along much of this deformation front (USGS, 2019). Figure 3.2 depicts the seismicity of the region showing that most earthquakes in South America occur within 500 km from the west coast.

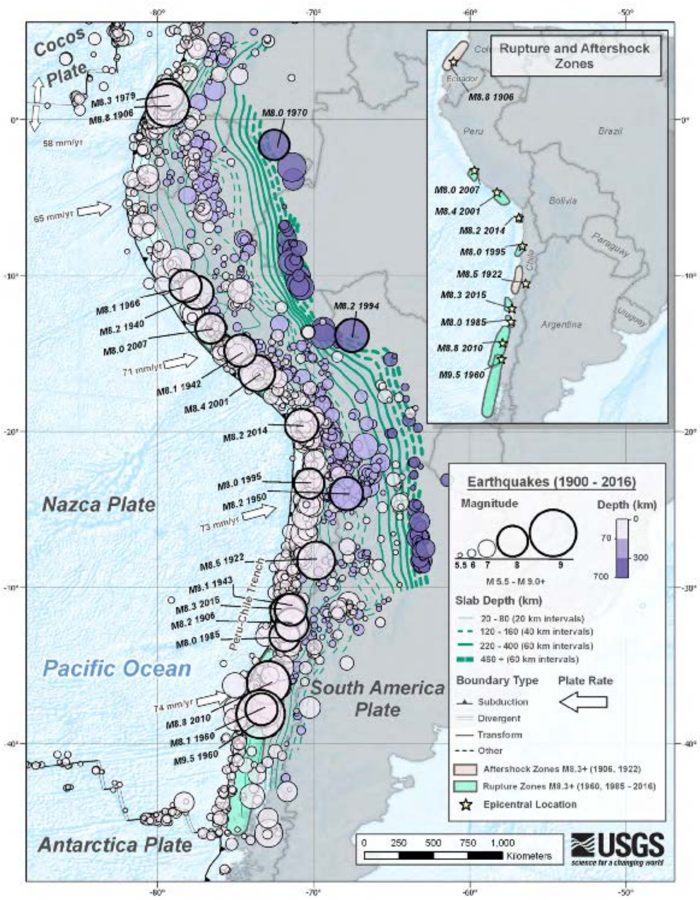


Figure 3.2. Seismicity of the region showing the date, location and magnitude of large earthquake in South America (USGS, 2019).

The subduction of the Nazca plate under the South America plate produces two main types of earthquakes: (1) Interplate shallow earthquakes occurring in the interface of the two plates; and (2) Intraplate intermediate-depth normal faulting events happening within the Nazca plate. The May 26th, 2019 event belongs to this second type of subduction earthquakes.

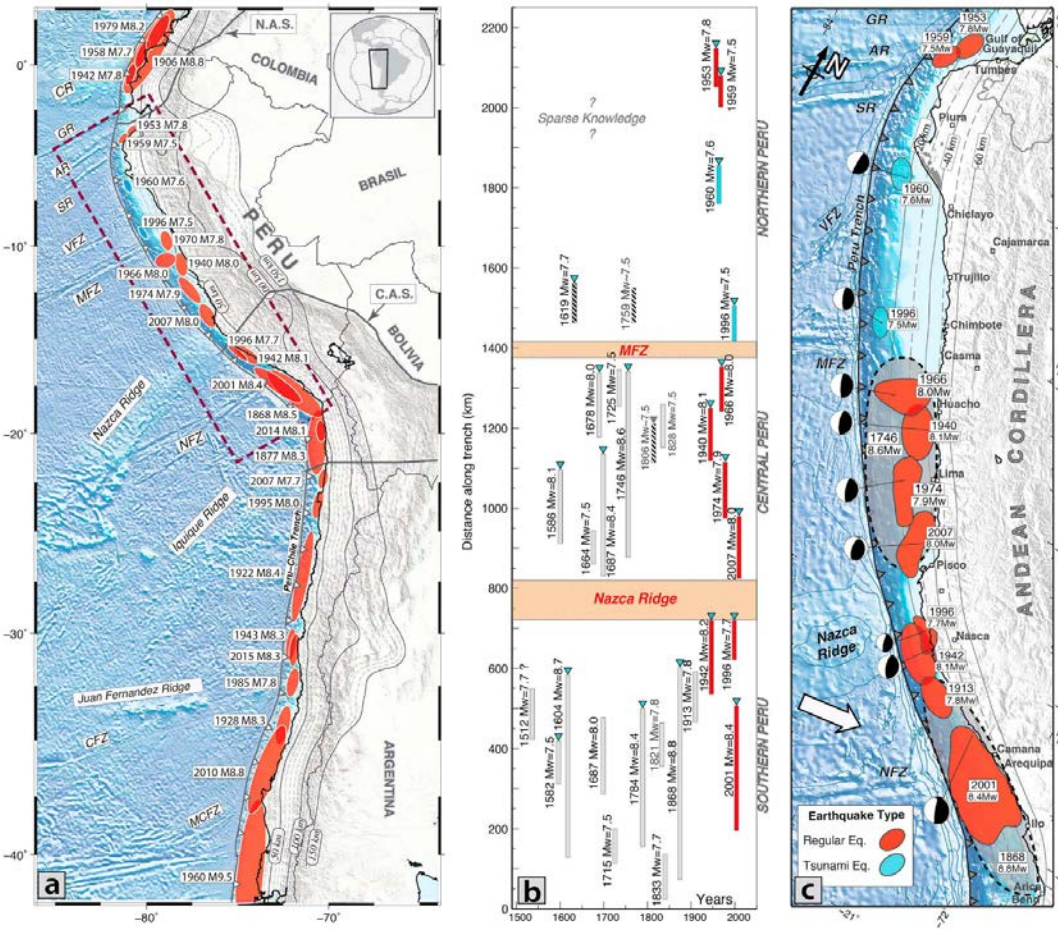


Figure 3.3. Left: Historical seismicity for large earthquakes (M > 7.5) in the Peruvian-Chilean subduction fault. Center: Closeup view of the rectangular area in the left figure, highlighting the seismic activity and seismic gaps in Perú during the last 5 centuries. Right: Closeup view of the rectangular area in the left figure showing the rupture areas of the most recent and largest earthquakes in the region. (Extracted from Villegas et al., 2016.)

Interplate earthquakes occur due to slip along the dipping interface between the Nazca and the South American plates. Interplate earthquakes in this region are frequent and often large, and occur between the depths of approximately 10 and 60 km. Since 1900, numerous magnitude 8 or larger earthquakes have occurred on this subduction zone interface that were followed by devastating tsunamis, including the 1960 M9.5 earthquake in southern Chile, the largest instrumentally recorded earthquake in the world. Other notable shallow tsunami-generating earthquakes include the 1906 M8.5 earthquake near Esmeraldas, Ecuador, the 1922 M8.5 earthquake near Coquimbo, Chile, the 2001 M8.4 Arequipa, Perú earthquake, the 2007 M8.0 earthquake near Pisco, Perú, and the 2010 M8.8 Maule, Chile earthquake located just north of the 1960 event (USGS, 2019). Some of the main event interplate earthquake along the subduction trench are shown in Figure 3.3.

Large intermediate-depth earthquakes, on the other hand, (those occurring between depths of approximately 70 and 300 km) are relatively limited in size and spatial extent in South America, and occur within the Nazca plate as a result of internal deformation within the subducting plate. These earthquakes generally cluster beneath northern Chile and southwestern Bolivia, and to a lesser extent beneath northern Perú and southern Ecuador, with depths between 110 and 130 km. Most of these earthquakes occur adjacent to the bend in the coastline between Peru and Chile. The most recent large intermediate-depth earthquake in this region was the 2005 M7.8 Tarapaca, Chile earthquake (USGS, 2019).

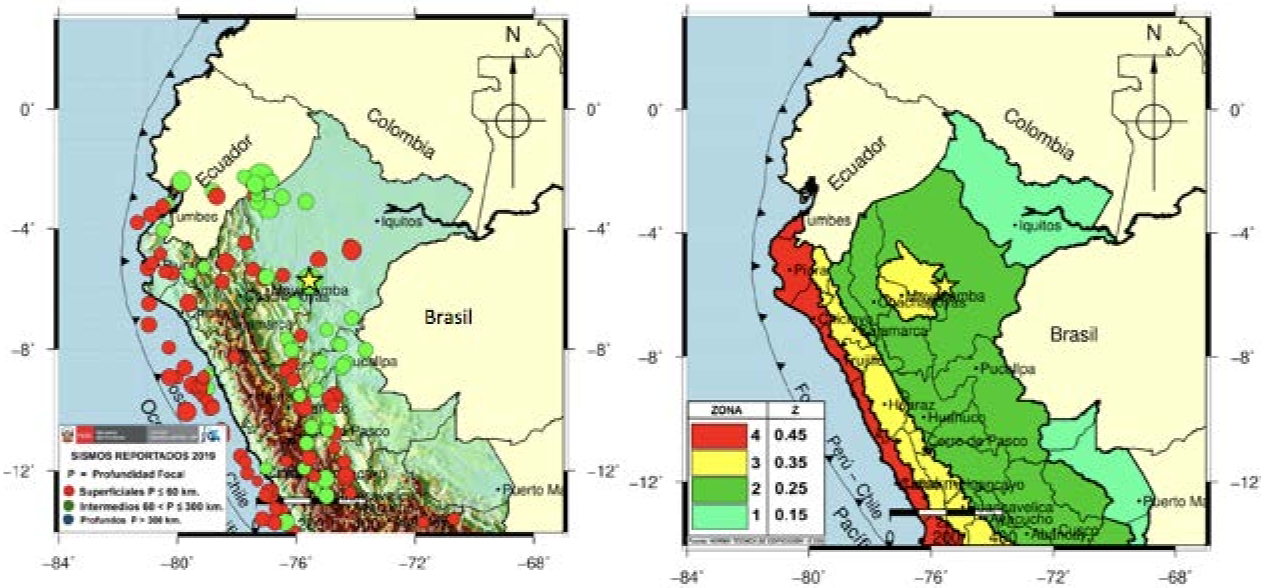


Figure 3.4. Left: Seismicity in Perú and Ecuador showing the location and depth of the events during the first five months of 2019 (Lagunas event marked with a yellow star). Right: Seismic zones in the region. (After Instituto Geofísico del Perú, IGP http://intranet.igp.gob.pe/bdsismos/downloads/5391-mapa.pdf).

The map on the left side of Figure 3.4 provides a closer and more recent look at the seismicity of Northern Perú. The red circles depict shallow events (depth < 60 km), while the green circles depict intermediate-depth events like the event of this VAST report. All events shown in this figure occurred in the first five months of 2019. The yellow star marks the epicenter of the May 26, 2019 Lagunas earthquake. According to the Peruvian seismic zonation, this event took place in a region of moderate seismicity between regions 2 and 3 (Fig. 3.4 right).

3.2 Earthquake details

The USGS origin report shows a fault mechanism in accordance with the intermediate-plate normal fault of the region (Fig. 3.5). The moment release was quantified as 1.14e21 N-m that corresponds to a Mw 8.0.

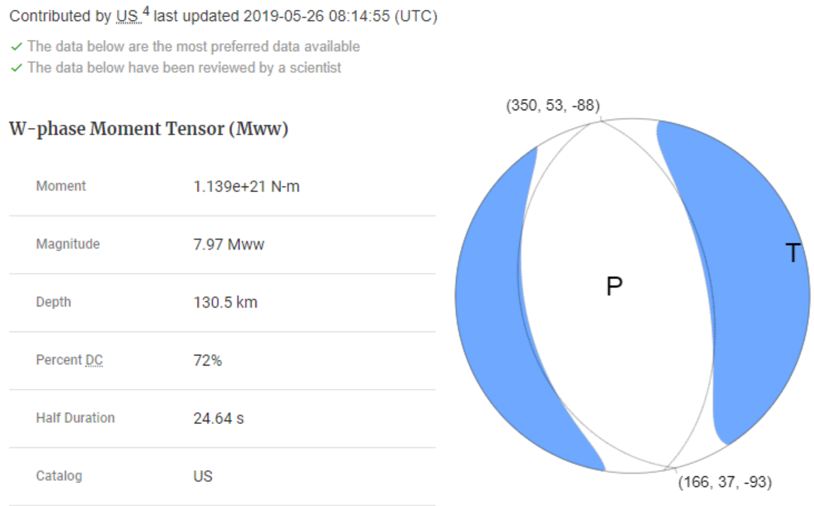


Figure 3.5. Moment tensor (USGS, 2019).

According to the USGS preliminary finite fault analysis, the rupture process took around 60 s with biggest moment release occurring between 40-60 s. The average slip was around 1.5 m as shown in Fig. 3.6 (USGS, 2019).

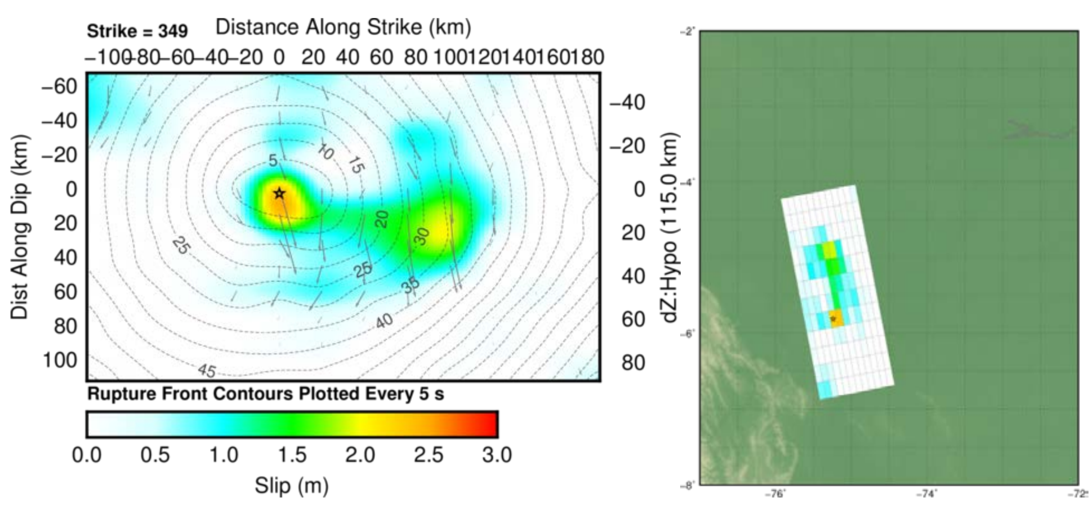


Figure 3.6. Rupture inversion plane. Left: Cross-section of slip distribution along the rupture. Right: Surface projection (USGS, 2019).

The Shakemap produced by the USGS (Fig. 3.7) indicates estimated maximum Peak Ground Accelerations (PGA) in the range of 0.4g~0.5g and the Intensity levels of up to VIII. Circles in this map correspond to location of sites where USGS's "Did you Feel It, DYFI" information was reported. More information of recorded ground motions and DYFI information is presented in the following sections.

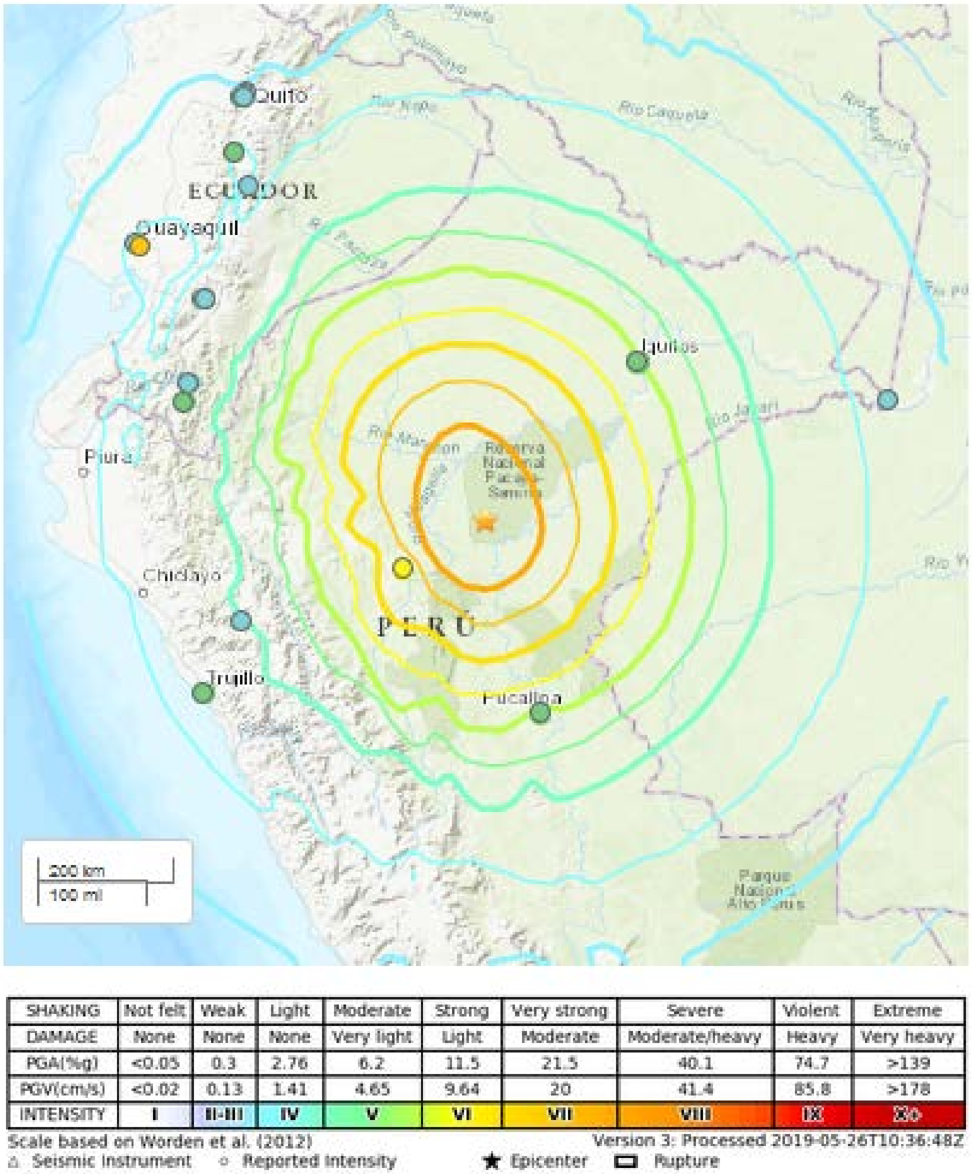


Figure 3.7. USGS Shakemap (USGS, 2019).

4. Recorded Ground Motions

This section describes the ground motion records provided by the Centro Peruano-Japonés de Investigaciones Sísmicas y Mitigación de Desastres (CISMID), refer to Fig. 4.1, the Colegio de Ingenieros del Perú, and the Universidad Nacional de Ingeniería (CIP-UNI). CISMID is a collaborative research center between Perú and Japan devoted to Earthquake Engineering and Disaster Mitigation, which is supported by the Japan International Cooperation Agency (JICA) and is located at the National University of Engineering (UNI by its initials in Spanish) in Perú. Along with several institutions in Perú, they operate a network of more than 50 accelerographs, with more than half of them located within the Lima metropolitan Region (the capital of Perú). Table 4.1 presents a summary of the most significant PGA's recorded in their network.

Table 4.1. Most significant peak ground accelerations recorded in the CISMID network (CISMID–FIC–UNI Y SENCICO, 2019).

Orientación	Ubicación (Distrito, Provincia, Departamento)	PGA (cm/s^2)
EO	Gerencia Zonal de SENCICO - HUANCAYO	-8.00
NS		-6.97
UD		5.18
EO	Gerencia Zonal de SENCICO - ICA	5.56
NS		6.76
UD		-3.84
EO	Gerencia Zonal de SENCICO - IQUITOS	-81.08
NS		75.98
UD		67.55
EO	Gerencia Zonal de SENCICO - PIURA	20.84
NS		16.33
UD		11.09
EO	Gerencia Zonal de SENCICO - TRUJILLO	44.67
NS		-39.08
UD		24.13
EO	Gerencia Zonal de SENCICO - LIMA	7.89
NS		8.08
UD		-6.93

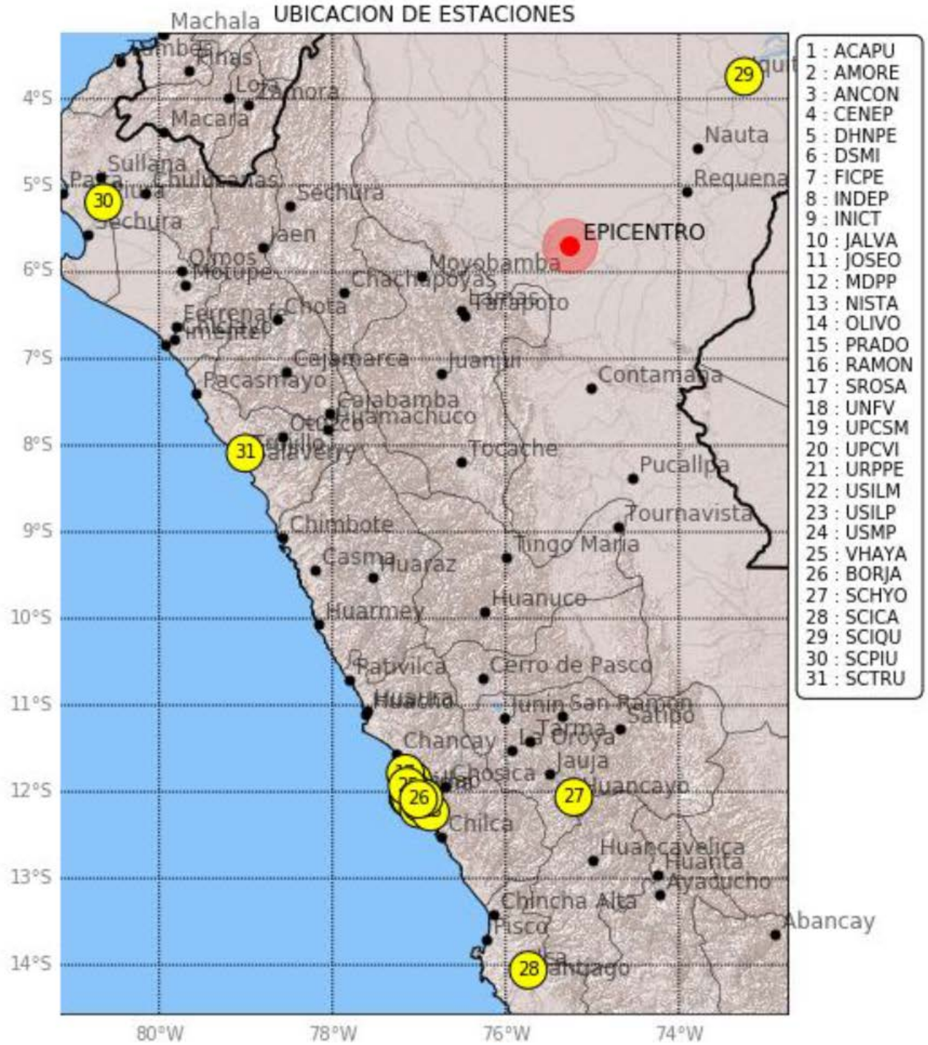


Figure 4.1. Location of stations from the CISMID network that recorded the event (CISMID–FIC–UNI Y SENCICO, 2019).

The Colegio de Ingenieros Civiles de Perú (CIP) in a collaboration with Universidad Nacional de Ingeniería (UNI) operate another accelerograph network with 61 digital accelerometers (CIP-UNI, 2019). Table 4.2 presents the highest registered PGA’s from this network. The locations of each station are depicted in Figure 4.2.

Table 4.2. Highest peak ground accelerations recorded in the CIP-UNI network (CIP–UNI, 2019).

Institution	Station	Location	Soil type	Peak Ground Accelerations after filtering (cm/s^2)			PGA max	PGA max
				EW	NS	UP	cm/s^2	g
POSGRADO FIC UNI / UNTRM	UNTRM	AMAZONAS, CHACHAPOYAS, CHACHAPOYAS	High compressibility Clay	95.84	87.45	53.49	95.84	0.098
CIP	CIP MOYOBAMBA	SAN MARTIN, MOYOBAMBA, MOYOBAMBA	Clay	91.29	78.76	90.16	91.29	0.093
CIP	CIP TARAPOTO	SAN MARTIN, SAN MARTIN, TARAPOTO	High compressibility Clay	58.18	79.56	67.86	79.56	0.081
CIP	CIP AMAZONAS	AMAZONAS, CHACHAPOYAS, CHACHAPOYAS	High compressibility Clay	78.91	53.98	53.05	78.91	0.08
UNIVERSIDAD SAN PEDRO	USP	ANCASH, SANTA, CHIMBOTE	Sand	44.93	42.58	24.39	44.93	0.046
CIP	CIP HUANUCO	HUANUCO, HUANUCO, HUANUCO	Gravel with clay	40.11	42.61	19.6	42.61	0.043
POSGRADO FIC UNI	PACASMAYO	LA LIBERTAD, PACASMAYO, PACASMAYO	Gravel with sand	38.07	25.02	17.99	38.07	0.039

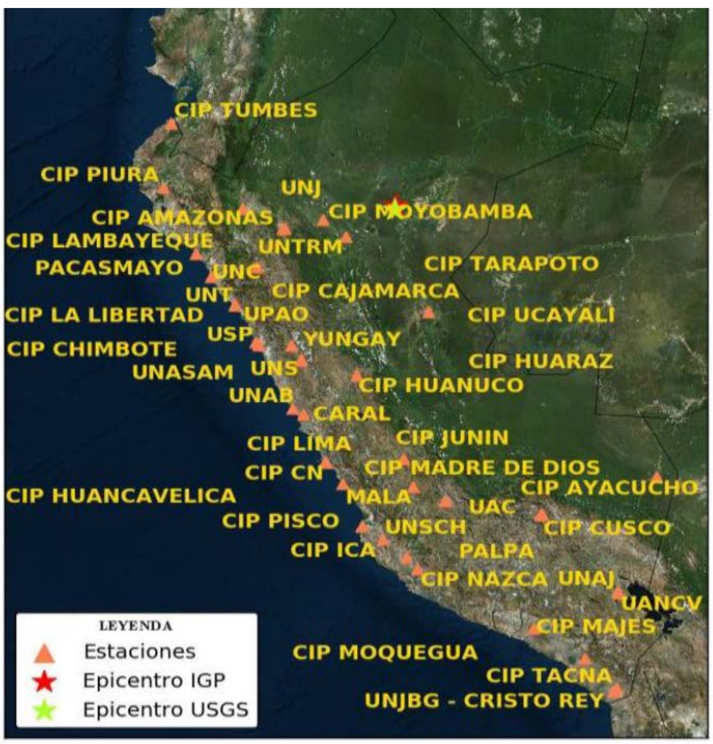


Figure 4.2. Location of accelerograph stations of the CIP-UNI network (CIP-UNI, 2019).

Figures 4.3 to 4.6 show the acceleration time series of the ground motions at the two stations that recorded the largest PGAs of each network. These records were obtained in the cities of Moyobamba (station CIP-MOYOBAMBA), Trujillo (station SENCICO-TRUJILLO), Iquitos (station SENCICO-IQUITOS), and Chachapoyas (station CIP-UNTRM). Each figure is presented as provided by the institutions operating these networks.

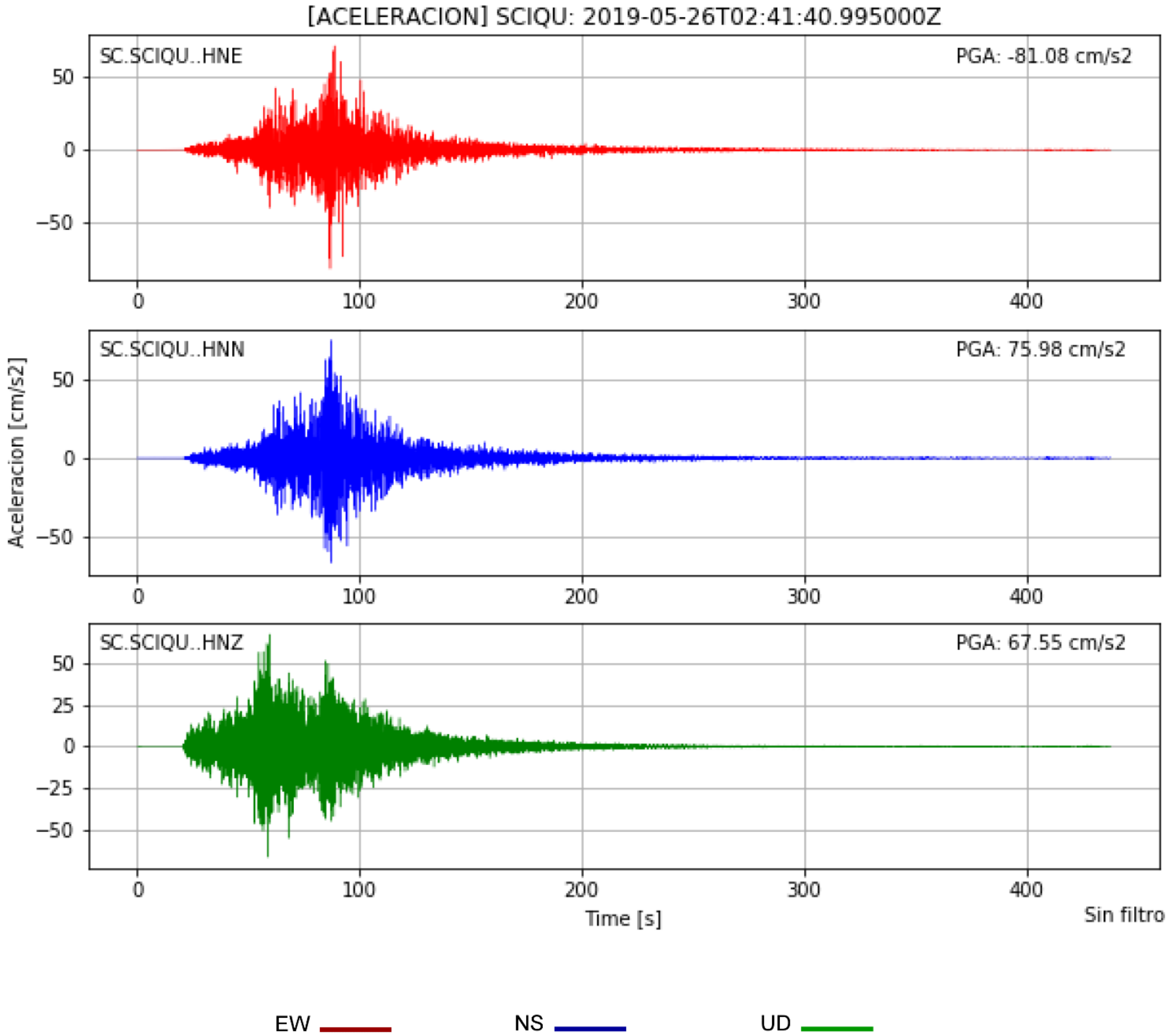


Figure 4.3. Acceleration time series of each component recorded in the city of Iquitos at station SENCICO-IQUITOS (CISMID–FIC–UNI Y SENCICO, 2019).

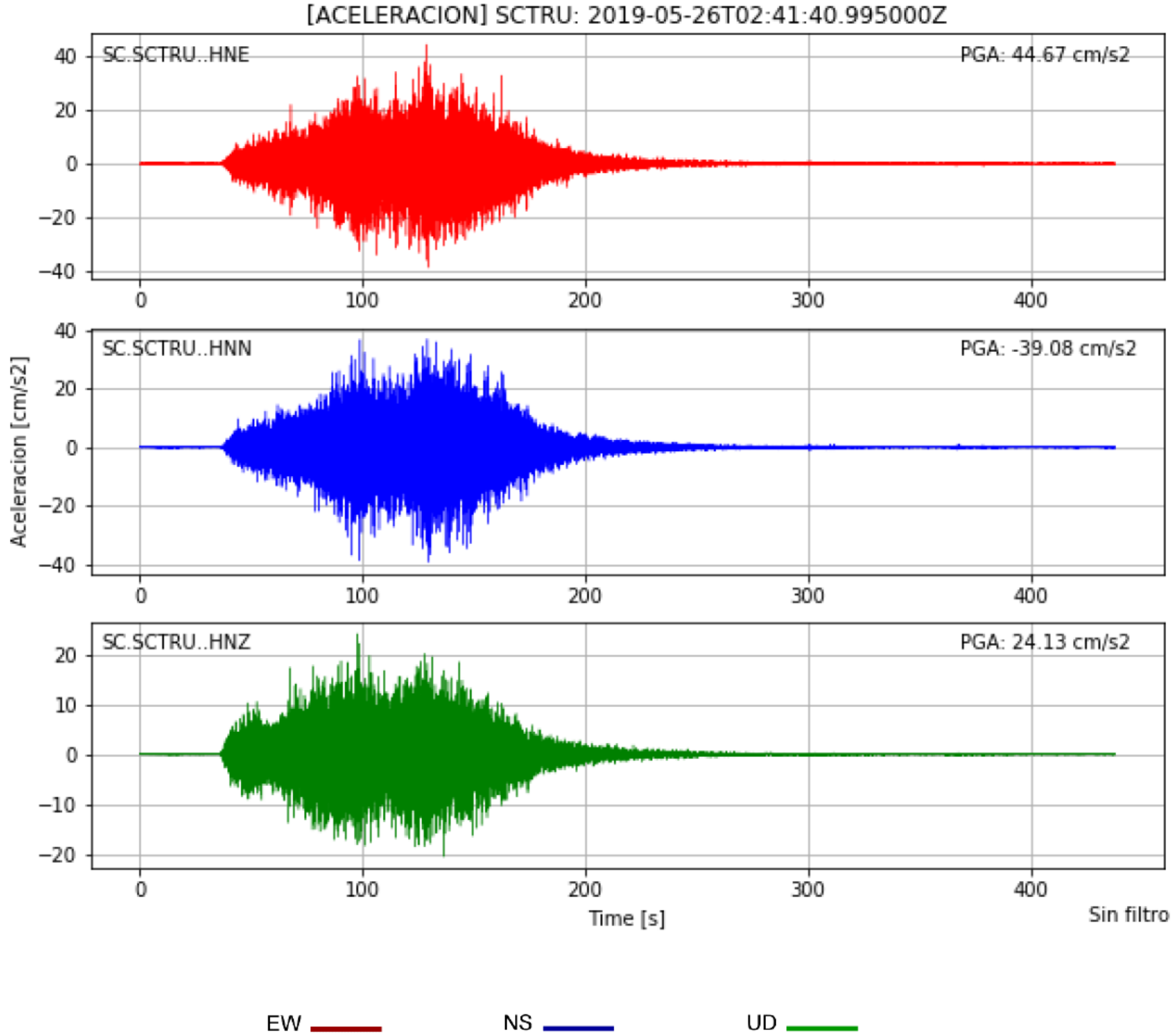


Figure 4.4. Acceleration time series of each component recorded in the city of Trujillo at station SENCICO-TRUJILLO (CISMID–FIC–UNI Y SENCICO, 2019).

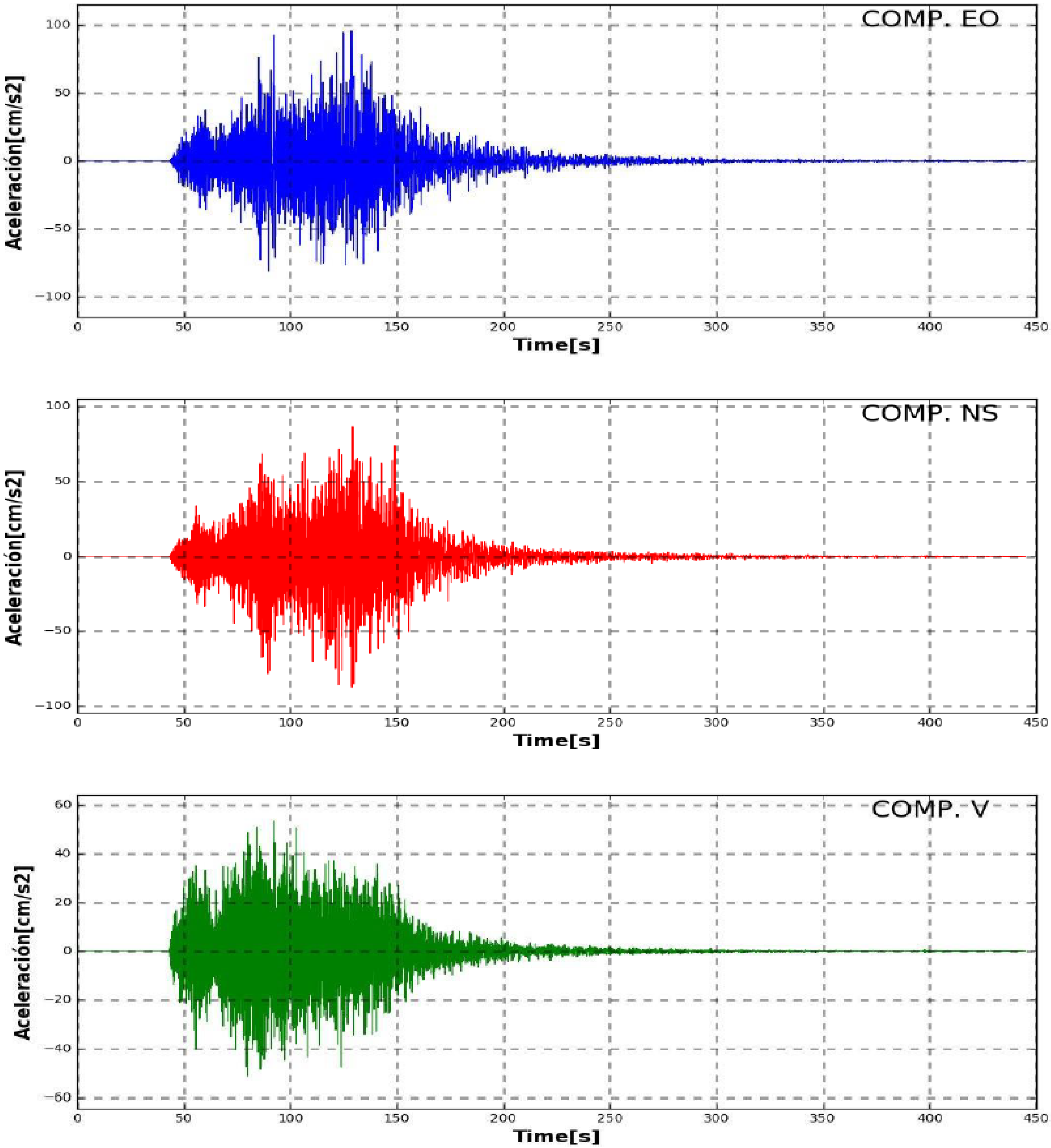


Figure 4.5. Acceleration time series of each component recorded in the city of Chachapoyas at station CIP-UNTRM (CIP–UNI, 2019).

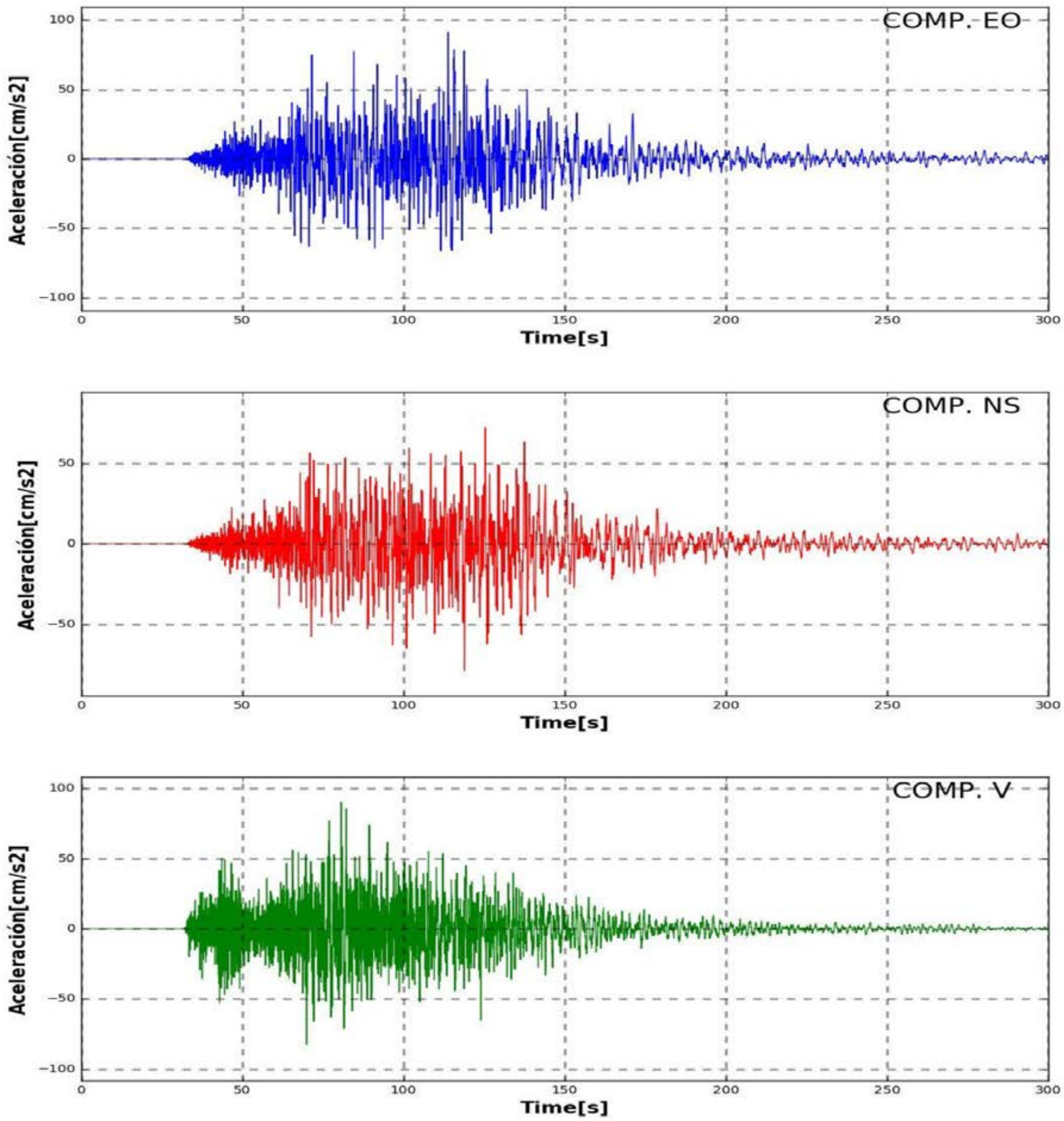


Figure 4.6. Acceleration time histories of each component recorded in the city of Moyobamba at station CIP-MOYOBAMBA (CIP–UNI, 2019).

Ground motions from the CISMID network were post-processed to remove instrument noise and to retrieve the actual ground motions. The correction procedure that we conducted is summarized in the following steps:

1. Subtract the mean acceleration in the pre-event portion of the record, a procedure often referred to as basic baseline correction;
2. Decimate the record to 200 samples per second;
3. Add pre- and post-event zero-pads following recommendations by Converse and Brady (1992);
4. Apply an acausal bandpass Butterworth filter of order 6 (filtered twice with order 3) with a low-cut frequency of 0.10 Hz and a high-cut frequency of 25 Hz.

More involved baseline corrections (piecewise linear or quadratic) beyond that indicated in step one were not required since coseismic displacements are not expected in ground motions recorded at these large distances from the hypocenter.

Ground motions provided by CIP-UNI had already been baseline corrected and bandpass filtered with a low-cut frequency of 0.10 Hz and a high-cut frequency of 25 Hz. Therefore, no further processing was required for computing response spectra.

4.1 Response spectra

Figure 4.7 presents median spectral ordinates estimated for a Mw 8.0 event at a hypocentral depth of 110 km for varying closest distance to the fault surface between 100 km and 500 km. The moment magnitude and approximate hypocentral depth correspond to those of the May 26th 2019 Lagunas earthquake. These predictions were computed using the García et al. (2005) ground motion prediction equation (GMPE) which is applicable to free-field rock sites for intermediate-depth, normal faulting inslab earthquakes.

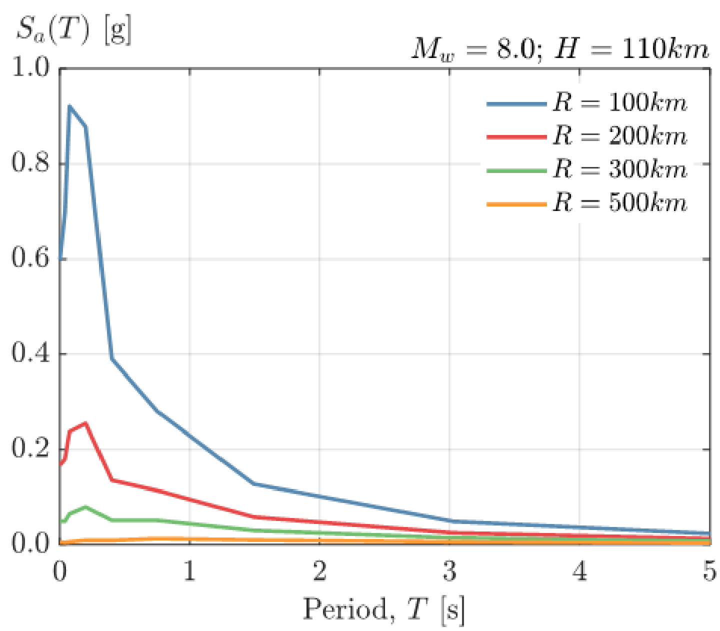


Figure 4.7. Median pseudo-acceleration spectral ordinates estimated for four different source-to-site distances, for an intermediate-depth intraplate event with $M_W = 8.0$, and hypocentral depth of 110 km, using the GMPE developed by García et al. (2005).

Figure 4.8 shows the attenuation of the median, the 16th, and 84th percentiles PGA predictions using the García et al. (2005) GMPE, compared with the PGAs in the east-west (EW) and north-south (NS) components recorded at 34 stations in Perú. As expected, the amplitude of the recorded PGA values decreases with increasing distance. However, it does not decrease at the same rate as the median GMPE prediction suggests. This considerable difference in amplitude between the predictions from the GMPE and the observations, particularly at large distances, is partly attributed to varying local conditions at recording stations in this event (several of which were recorded on highly compressible clay deposits) while the García et al. model was developed for rock sites, but also due to the fact that the GMPE was developed based on 277 free-field ground motions recorded on rock sites during 16 intermediate-depth intraplate events in Mexico's Cocos plate of Mw between 5.2 and 7.4 at distances only up to 400 km. Therefore, both the magnitude and most of the distances to the recording stations in this event and shown in Fig. 4.8 are well outside of the recommended range for this GMPE. Similar information, but now corresponding to the 5% damped pseudo-acceleration spectral ordinates for periods of vibration of 0.1 s and 1.0 s, is presented in Figures 4.9 and 4.10. Again, the observations in most cases are larger than those predicted by the GMPE.

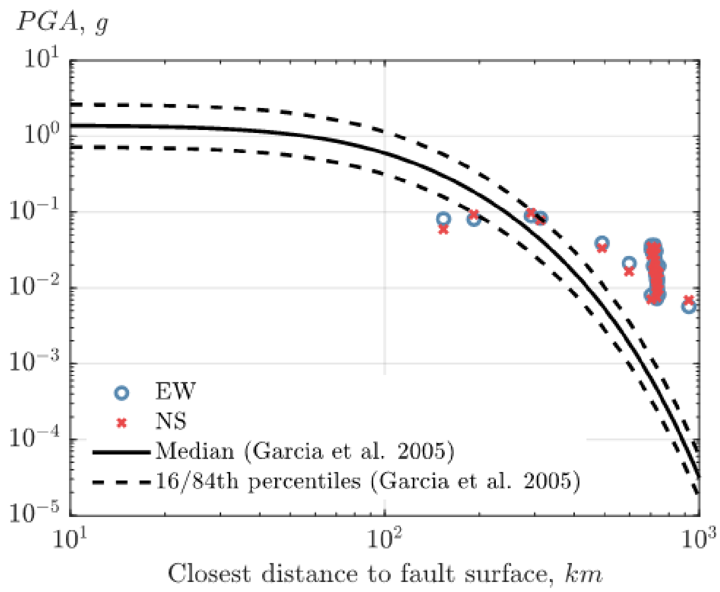


Figure 4.8. Variation of median, 16th, and 84th percentiles PGA estimated with the GMPE developed by Garcia et al. 2005, compared to recorded PGAs at 34 Peruvian stations during the 2019 Lagunas event.

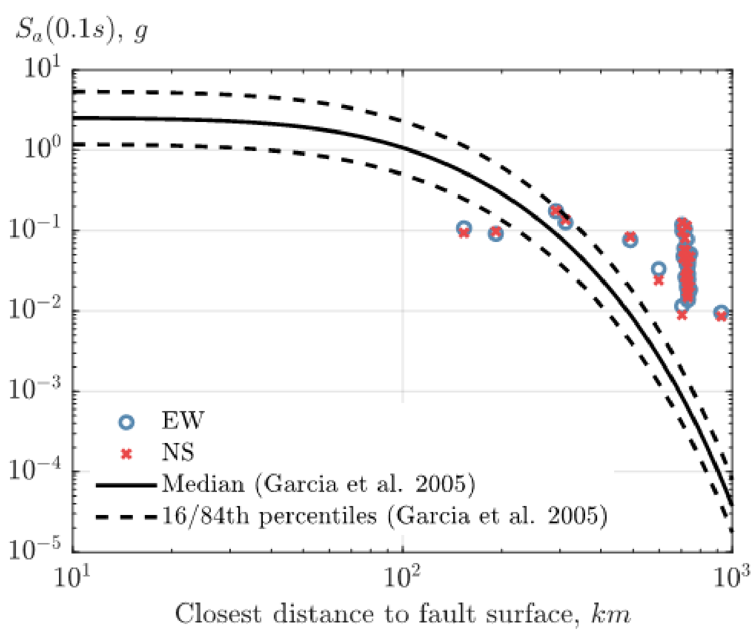


Figure 4.9. Variation of median, 16th, and 84th percentiles short-period spectral acceleration (at a period of 0.1 s) estimated with the GMPE developed by Garcia et al. 2005, compared with spectral ordinates computed from recordings of 34 Peruvian stations during the 2019 Lagunas earthquake.

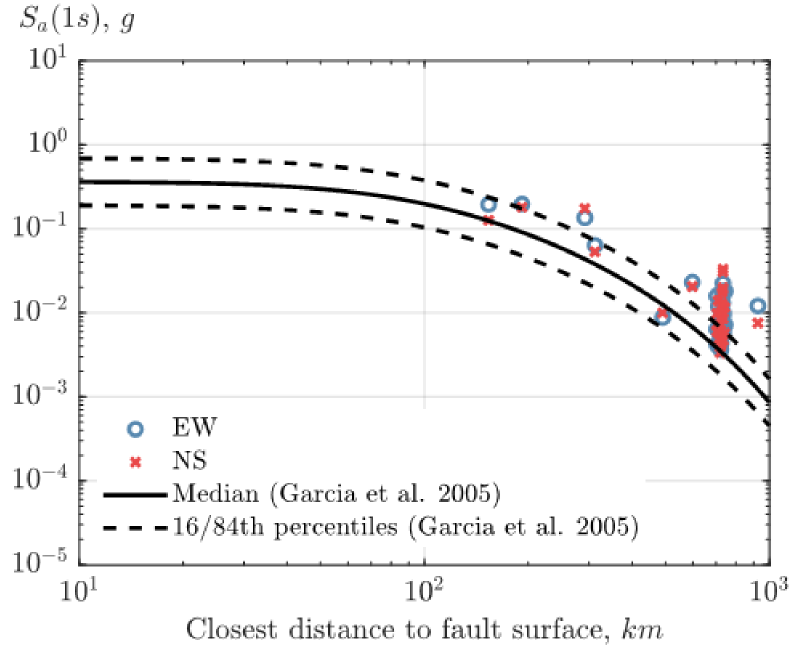


Figure 4.10. Variation of median, 16th, and 84th percentiles intermediate-period spectral acceleration (at a period of 1.0 s) estimated with the GMPE developed by Garcia et al. 2005, compared with spectral ordinates computed from recordings of 34 Peruvian stations during the 2019 Lagunas earthquake.

Figure 4.11 shows the median spectral ordinates predicted by the García et al. (2005), the Montalva et al. (2017), and BC Hydro (Abrahamson et al. 2016) GMPEs, along with the pseudo-acceleration spectra of NS and EW components of the acceleration time series recorded at four different stations. In the case of the Montalva et al. (2017) and BC Hydro models, a V_{S30} value of 200 m/s was used, which is consistent with the soil type in the two sites presented in the upper row. The upper left subfigure corresponds to a station in the city of Moyobamba, located at an epicentral distance of 192 km. The upper right subfigure corresponds to the station in the city of Chachapoyas which is located at 292 km from the epicenter. The two bottom subfigures correspond to stations in the cities of Iquitos and Trujillo, located at epicentral distances of 312 km and 490 km, respectively. The first three are located in the back-arc region (i.e., east of Los Andes) while the latter is located on the coast in the forearc region. In general, all three GMPEs underestimate the pseudo-acceleration spectral ordinates computed from these records, especially for the intermediate and long period range in the station of Moyobamba and the short and intermediate period range in the other three sites. These underestimations can reach factors of more than three, especially in the short period range of the two stations located farthest away from the epicenter.

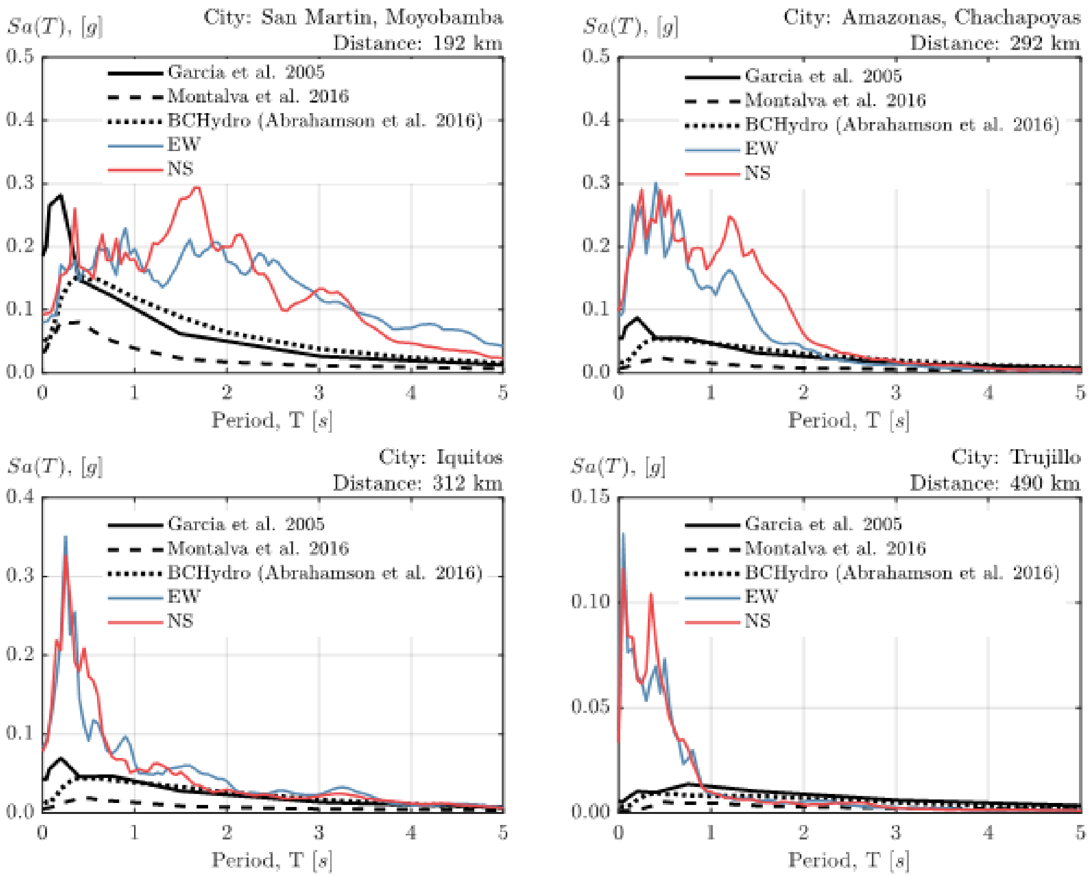


Figure 4.11: Response spectra of recorded ground motions, along with median predictions from the García et al. (2005), Montalva et al. (2017) and BC Hydro (Abrahamson et al. 2016) GMPEs, using VS30 = 200m/s (consistent with soil type at stations in Moyobamba and Chachapoyas).

4.2 Strong motion duration inferred from Husid plots

Although several of the ground motion records from this event (those from four stations shown in figures 4.2 to 4.6) have durations in excess of 400 s, not all of this duration correspond to strong motion. Figure 4.12 shows Husid plots (Husid, 1969) which provide a measure on the time history of the energy input of a record. These plots are computed as the integral of accelerations squared from the beginning of the record to time t and therefore, by definition, are ascending curves. It can be seen that while the ground motions at Moyobamba and Chachapoyas have strong motion durations (e.g. D_{5-95}) of about 100s, the records at Iquitos and Trujillo have much shorter strong motion durations (i.e., of approximately 50s) despite having been recorded at distances farther away from the source.

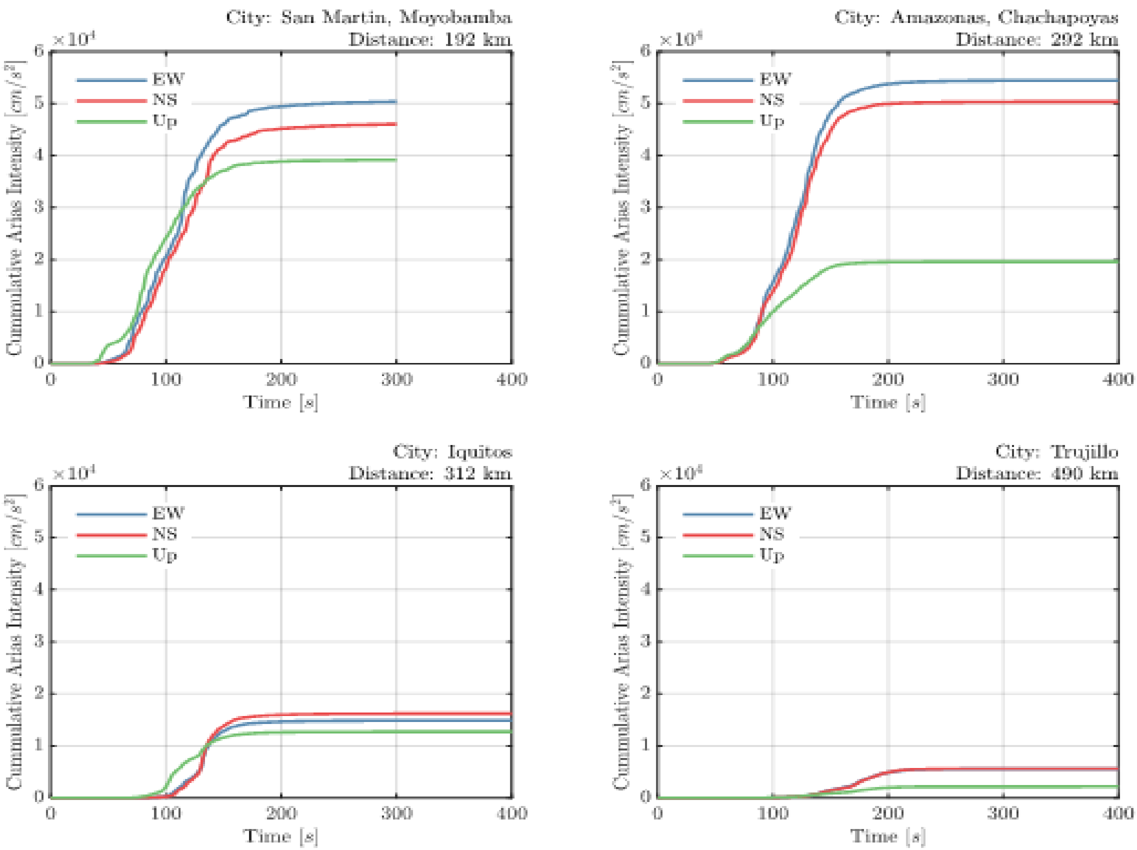


Figure 4.12 Husid plots computed from the ground motions recorded at stations in the cities of Moyobamba, Chachapoyas, Iquitos, and Trujillo.

4.3 Ground motions recorded in other countries

The earthquake produced ground motions not only in Perú, but also in other countries such as Ecuador and Colombia. Figure 4.13 shows the ground motion acceleration series recorded by the Guayaquil, Ecuador Network, kindly provided by the Instituto Geofísico, Escuela Politécnica Nacional. This city is at approximately 660 km from the epicenter. As can be observed, highest PGAs recorded in Guayaquil, Ecuador were about 0.04g, in stations GYGU and GYPS.

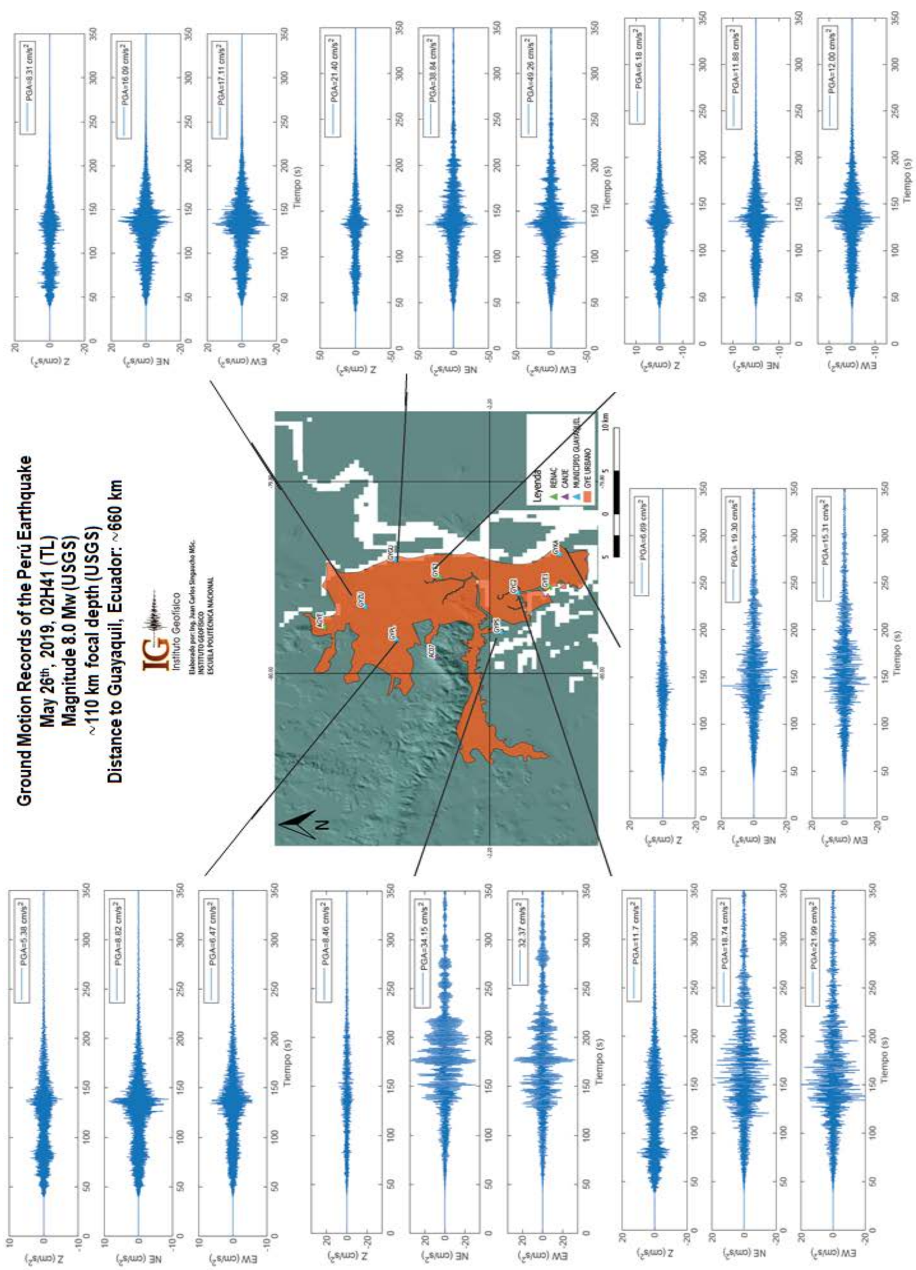


Figure 4.13. Acceleration time series recorded at stations of the Guayaquil, Ecuador network(modified from original figure developed by Juan Carlos Singaucho).

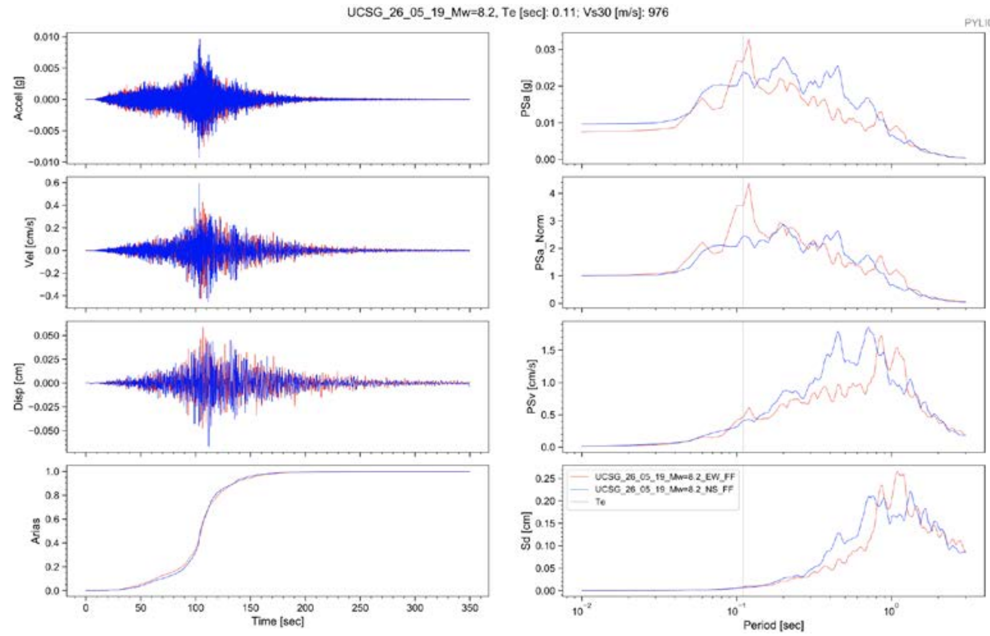


Figure 4.14 Acceleration time histories, Husid plots and response spectra from ground motions recorded at the accelerograph station located on the campus of the Catholic University of Santiago de Guayaquil (UCSG) on a rock outcrop (Dr. Xavier Vera, personal communication).

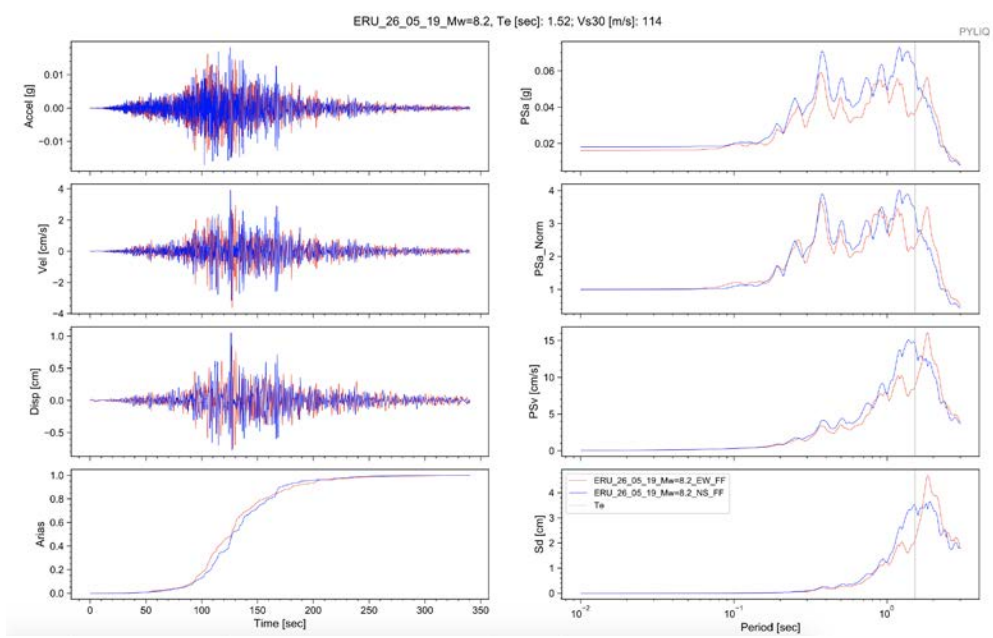


Figure 4.15 Acceleration time histories, Husid plots and response spectra from ground motions recorded at the Ramón de Unamuno accelerograph station (ERU) located on soft soil deposits in Guayaquil (UCSG) (Dr. Xavier Vera, personal communication).

Ground motions in the city of Guayaquil are of particular interest as most of the city is built on very soft soil clay deposits. The city is located mainly on the left bank of the Guayas River and is the largest urban area in Ecuador, with a population of more than 2.3 million. Similarly to Mexico City, Guayaquil is susceptible to suffer damage even from very distant earthquakes. For example, several fatalities and collapses along with a large amount of damage were produced in the city as a result of the April 16, 2016 Mw 7.8 Muisne earthquake, despite being 286 km away from the epicenter (approximate shortest distance to the rupture was 170 km). Although with smaller water contents, smaller plasticity indices and larger shear wave velocities than soft deposits in Mexico City, the soft soils deposits in Guayaquil have produced large amplifications and are a major concern for the seismic risk in the City (Vera-Grunauer, 2014).

There are two accelerograph networks in the city of Guayaquil, one operated by the Instituto Geofisico Nacional (IGN), and the other operated by Universidad Católica de Santiago de Guayaquil (UCSG). Figure 4.14 shows acceleration times histories along with Husid plots and response spectra computed from ground motions recorded on the UCSG campus which is built on a sedimentary rock outcrop locally known as the “cayo formation”. Figure 4.15 shows acceleration times histories along with Husid plots and response spectra computed from ground motions recorded at the Ramón Unamuno sports park (ERU station) on deep soft deltaic estuarine clay deposits (Vera-Grunauer, 2014). As shown in this figure, these soft soil deposits significantly modify the intensity and frequency content of the ground motions leading to large acceleration and displacement demands, particularly for structures whose periods of vibration are similar to those of the fundamental period of the soil deposit which for this station is approximately 1.5s.

5. “Did you feel it?” Reports

“Did You Feel It?” (DYFI) is a system operated by the USGS that was developed to tap the abundant information available about earthquakes from the people who experience them. By taking advantage of the vast number of Internet users, it is possible get a more complete description of what people experienced during the earthquake, the effects of an earthquake, and the extent of damage (USGS DYFI).

The DYFI Map and related products produced by the USGS are created within minutes of each earthquake of magnitude 1.9 or greater. The origin information (location and time) of each earthquake is provided by the Advanced National Seismic System (ANSS) and its regional and national networks partners in the U.S. (USGS DYFI).

The following sections describe some of the maps created by USGS as a result of this earthquake. More recently, various Institutes of Geophysics and Seismological Centers in several other countries have developed similar systems and products. Results and information from this earthquake produced by these other centers are also described in the following sections. It is worth mentioning that these reports need to be analyzed with caution since they are subjective in nature and often characterized by large variability.

5.1 Perú and Ecuador

The DYFI survey available at the USGS website had around 1500 responses in the first 8 hours after the event. The responses came from people in Perú and Ecuador. The evolution over time of these responses is shown in Figure 5.1.

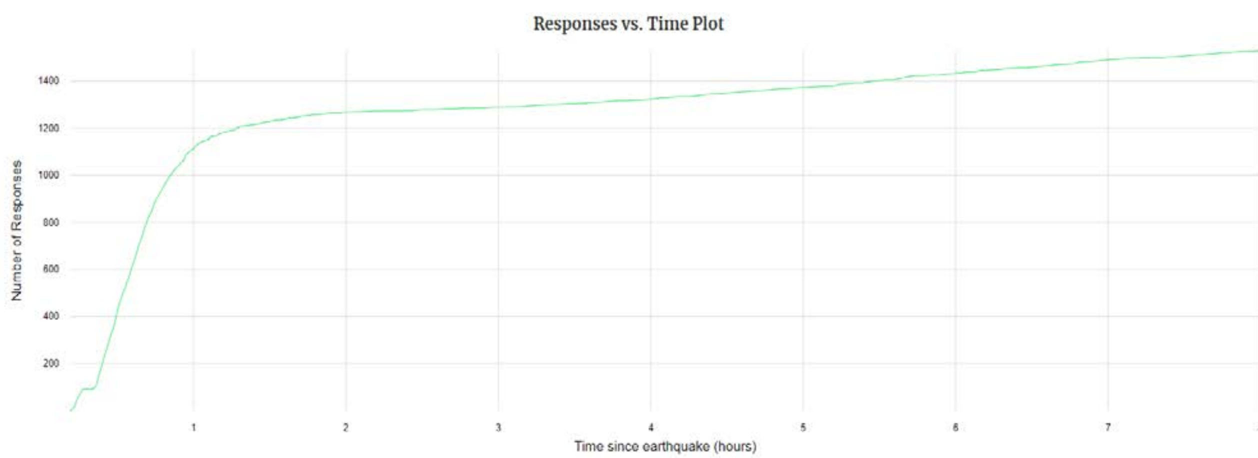


Figure 5.1: Did you feel it responses collected by the USGS (USGS, 2019)

Near the epicenter, there were reports of extreme shaking associated with very heavy damage. However, major cities in Perú and Ecuador did not report intensities beyond moderate (Figure 5.2 left). The attenuation of intensity with increasing hypocentral distance shows large dispersion.

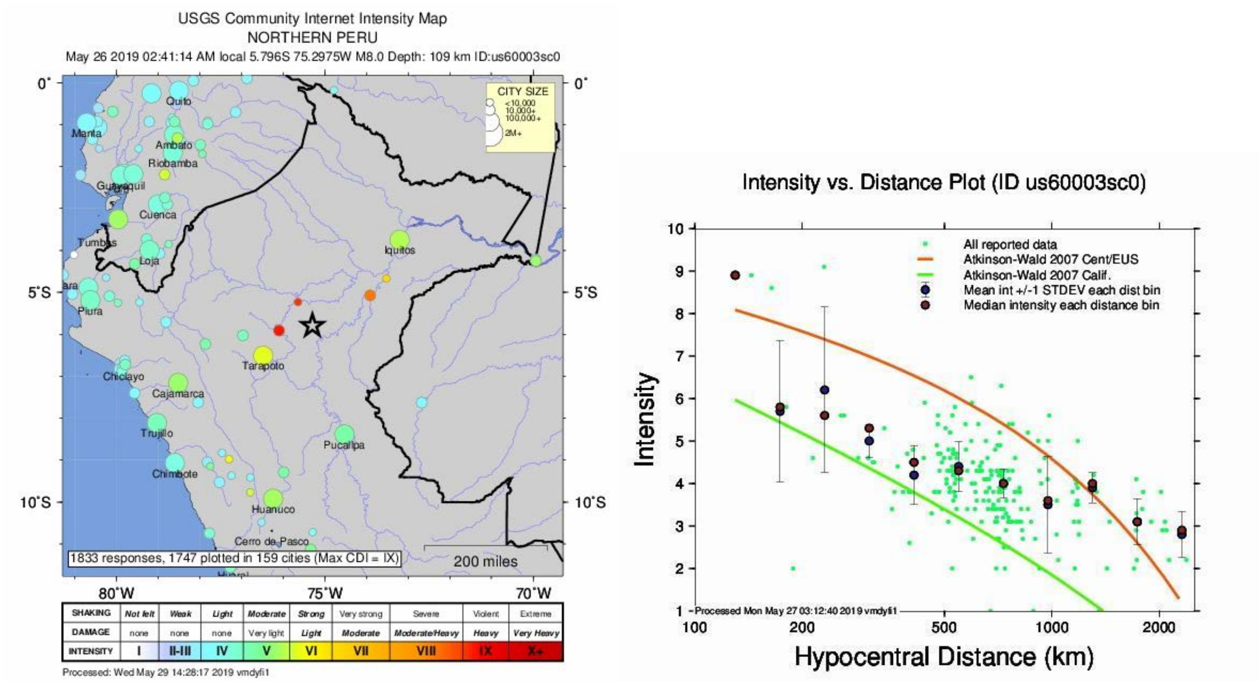


Figure 5.2: Left: Map of intensities inferred from DYFI responses in northern Perú and Ecuador. Right: Intensity vs hypocentral distance compared with empirical relationships (USGS, 2019).

The Instituto Geofísico Nacional del Ecuador (Ecuador's National Institute of Geophysics) also has developed a DYFI system and issued a report as a result of this earthquake based on 2875 individual reports. Ecuador has a total of 23 continental provinces as shown in Figure 5.3, with many regions experiencing strong intensities, especially those in the south-eastern portion of the country as shown in Figure 5.2. The most affected provinces were Azuay, Bolivar, Loja, Cañar, Tungurahua, Chimborazo, Guayas, El Oro and Zamora Chinchipe, where the earthquake was described as "strong – very strong". The estimated intensity in these regions varies between 4 to 5 in the European Macroseismic Scale (EMS). The residents indicated that the earthquake was characterized mainly by horizontal shaking that caused cups, lamps, and windows to be disturbed. In Guayaquil, a large city built largely on soft soil deposits and located 660 km from the epicenter, most were woken up by the earthquake and people indicated that they could hear the sloshing of the water in their cisterns.

Figure 5.3. Political map of Ecuador (Source: Wikimedia Commons).

In the provinces of Pichincha, Cotopaxi, Napo, and Pastaza the motion was described as "moderate – strong", however, it did not caused damage in buildings. The estimated intensity was 4 EMS. In other provinces such as Carchi, Imbabura, Esmeraldas, Manabi and Sucumbios, shaking was described as "light-moderate" which reflects an intensity of 3 EMS. In beach cities such as Salinas and Ballenita, located 800 km from the epicenter, most people did not feel the earthquake. No damage has been reported in these cities.

Likewise to the Ecuador Geological Survey, the Servicio Nacional de Gestión de Riesgos y Emergencias in Ecuador also published situation reports throughout the day of the event. This document reports minor effects in housing in Tantzaza and in Centinela del Condor communities located in Zamora Chinchipe. There were localized landslides in Morona Santiago km 42-San Juan Bosco, Orellana-Via el Coca and Azuay, where primary roads were blocked. Table 5.1 describes the intensities perceived throughout the country.

Table 5.1. Report of perceived intensity in Ecuador.

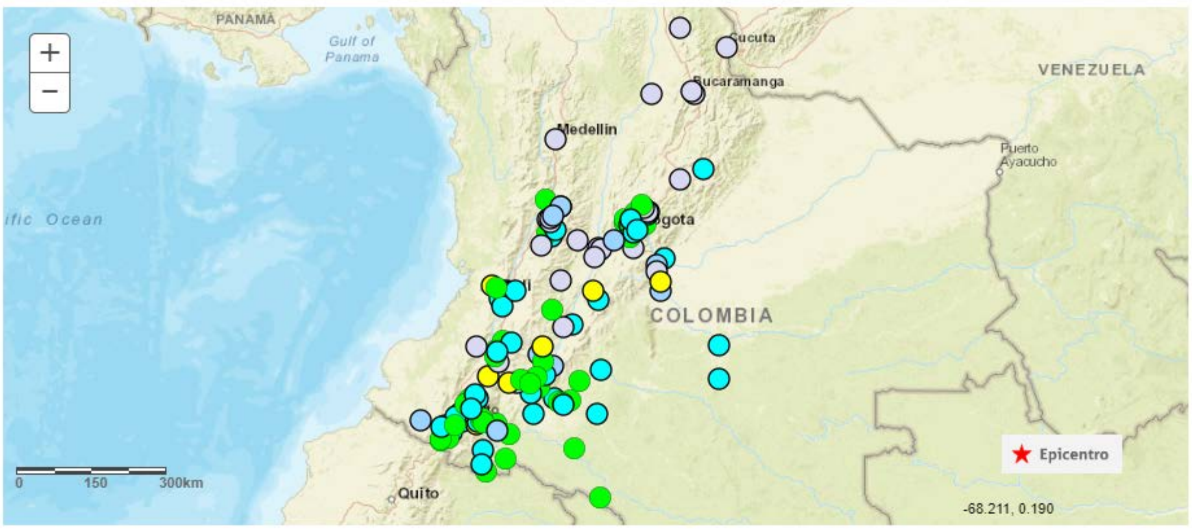
Reports of perceived intensity		
Intensity	**Province**	**Canton**

Strong	Bolivar	Guaranda, Chimbo, San Miguel, Chillanes, Echeandía, Las Naves, Caluma
	Chimborazo	Riobamba, Alausí, Colta, Chambo, Chunchi, Guamote, Guano, Pallatanga, Penipe, Cumandá
	Cotopaxi	Latacunga, La Mana, Pangua, Pujili, Salcedo, Saquisili, Sigchos
	Esmeraldas	Esmeraldas
	Loja	Calvas, Catamayo, Celica, Chaguarpamba, Espíndola, Gonzanamá, Loja, Macará, Olmedo, Paltas, Pindal, Puyango, Quilanga, Saraguro, Sozoranga, Zapotillo
	Los Rios	Quinsaloma, Urdaneta, Valencia, Ventanas, Vinces
	Manabi	Tosagua, Sucre, Santa Ana, San Vicente, Rocafuerte, Puerto López, Portoviejo, Pichincha, Pedernales, Paján, 24 De Mayo, Bolívar, Chone, El Carmen, Flavio Alfaro, Jama,Jaramijó, Olmedo, Jipijapa, Junín, Manta, Montecristi
	Morona Santiago	Gualaquiza, Huamboya, Limón Indanza, Logroño, Morona, Pablo Sexto, Palora, San Juan Bosco, Santiago, Sucúa, Taisha, Tiwintza
	Pastaza	Pastaza, Mera, Santa Clara, Arajuno
	Pichincha	Pedro Moncayo, Pedro Vicente Maldonado, Quito, Rumiñahui, San Miguel De Los Bancos
	Tungurahua	Ambato,Baños De Agua Santa,Cevallos,Mocha,Quero,San Pedro De Pelileo
	Zamora	Centinela Del Cóndor, Chinchipe, El Pangui, Nangaritza, Palanda, Paquisha, Yacuambí, Yantzaza, Zamora
Moderate	Azuay	Camilo Ponce Enriquez, Chordeleg, Cuenca, El Pan,Giron, Guachapala, Gualaceo, Guachapala, Santa Isabel, Nabon, Sevilla De Oro, Pucara, Paute
	Cañar	Azogues,Biblián,Cañar,Deleg,El Tambo,La Troncal,Suscal
	Guayas	Guayaquil, Samborondón, Lomas De Sargentillo, Isidro Ayora, Balzar, Nobol, Salitre (Urbina Jado), Milagro, Playas, El Triunfo, Naranjito, San Jacinto De Yaguachi, El Empalme, Alfredo
	Pichincha	Mejía,Puerto Quito
	Sto Domingo	Santo Domingo
	Tungurahua	Patate,Santiago De Píllaro,Tisaleo

5.2 Colombia

The Servicio Geológico Colombiano (Colombia Geological Survey) collected 2680 responses within 260 minutes of the event.

This event did not cause structural damage in Colombia. The reported damages in the yellow circles of Figure 5.4 are related to a few issues with non-structural elements. The shaking was felt mainly in the southern part of the country given the closer proximity to the epicenter. Nevertheless, the earthquake was felt as far as Bogotá, where people evacuated many buildings and reoccupied them a few hours after the event. Bogotá sits on deep (100 to 500m) soft soil (mostly clay) deposits that most likely amplified the ground motion. Figure 5.5 depicts the attenuation of seismic intensity, starting at around 600km away from the epicenter.



Intensity in scale EMS-98	Description
2	Just felt
3	Slightly felt
4	Widely felt
5	Strongly felt
6	Slight damage
7	Moderate damage
>7	Severe damage

Figure 5.4. Summary of intensities felt in Colombia (SGS, 2019).

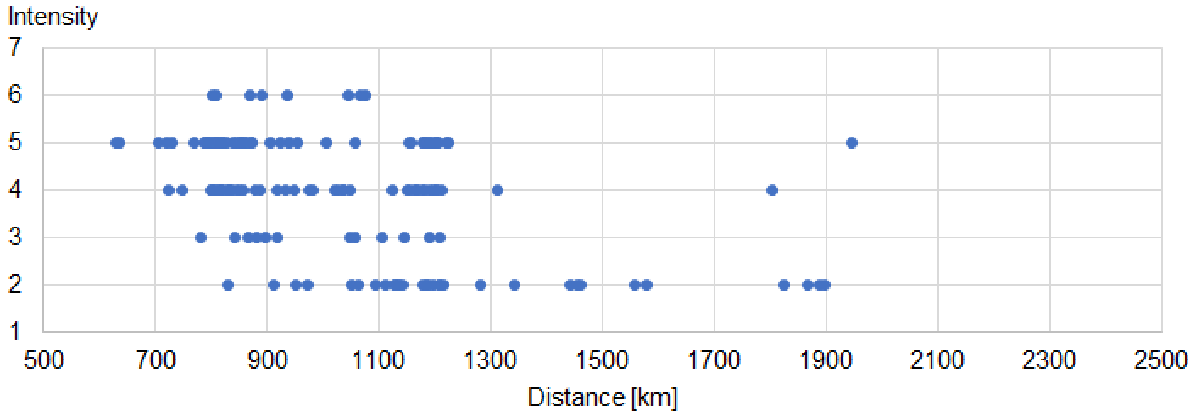


Figure 5.5. Intensity vs distance (SGS, 2019).

6. Local Codes and Construction Practices

Masonry and adobe are the most prevalent construction materials in Perú (Yepes-Estrada et al., 2017). These materials are mostly used in low-rise buildings. Confined masonry housing has been the most popular construction type in the urban regions of Peru in the last 50 years (Loaiza & Blondet, 2002). These buildings have load-bearing unreinforced clay masonry confined in the perimeter by small cast-in-place reinforced concrete tie/confining "columns" and beams. The tie/confining "columns" and tie/confining beams are cast after the masonry walls are built. The main purpose of the confining elements is to increase the deformation capacity of the masonry walls beyond the deformation that initiates diagonal cracking. Confined masonry buildings have limited shear strength, however, when properly detailed and built have shown to provide good seismic resistance and acceptable performance.

Construction in adobe, or "*construcción en tierra*" (construction with soil) as is locally known, is a traditional practice in Perú for over 200 years and can be found everywhere in the country, with higher density found in low-income regions (Loaiza, Blondet, & Ottazzi, 2002). Adobe walls are made of adobe blocks laid in mud mortar. The roof structure usually consists of timber beams with timber planks covered with a mud mortar overlay, clay tiles, or metal sheets.

Reinforced concrete buildings are less common since they are primarily used for medium- and high-rise buildings. In Peruvian construction practice, reinforced concrete is prefered over structural steel since the latter typically is more expensive in Perú.

Perú has had a seismic code since 1977. The latest version of this document, the Seismic Resistant and Design Code NTE.030, was approved in 2016 (Ministerio de Vivienda, 2016). This code is a modern seismic standard that incorporates chapters in seismic hazard, structural analysis, stiffness, strength and ductility requirements, and non-structural components. Figure 6.1 shows the different seismic zones in Perú included in the 2016 seismic code NTE.030, and Figure 6.2 shows the design spectra corresponding to each of these seismic zones. Though the seismic code has been available for several decades, it has not been appropriately enforced. The large urban growth in Perú has increased the building stock significantly in recent decades. A large percentage of these buildings was constructed without a proper engineering design and with low-quality construction practices, especially in the low-income regions, both in urban and rural areas.

Various studies and evidence from previous earthquakes have already demonstrated that these poorly-engineered and non-engineered buildings have high seismic vulnerability. The M_w 8.0 2007 Pisco earthquake in central Perú caused significant damage and multiple collapses in these types of buildings. Figure 6.3 shows and example of a collapse of a non-engineered adobe building after the Pisco earthquake. In contrast, buildings that were designed and constructed following the engineering standards in the seismic code performed significantly better. Multiple housing units, hospitals and schools built according to the seismic code had minor or no damage after the 2007 Pisco earthquake (Elnashai et al., 2008).

Figure 6.1. Map with the different seismic zones defined by the Peruvian seismic code NTE.030 (Ministerio de Vivienda, 2016).

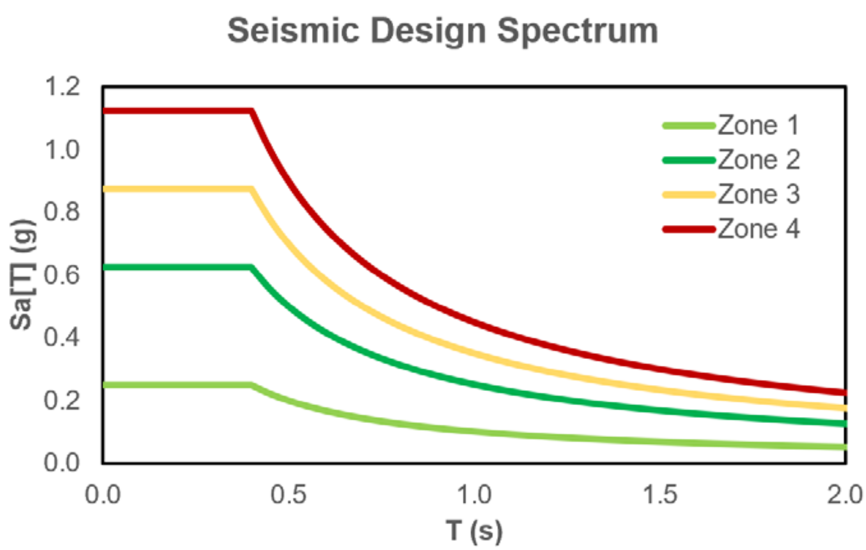


Figure 6.2. Seismic design spectra for the different seismic zones shown in Figure 6.1. The design spectra were estimated for rock and very rigid soils according to the Peruvian seismic code NTE.030 (Ministerio de Vivienda, 2016).

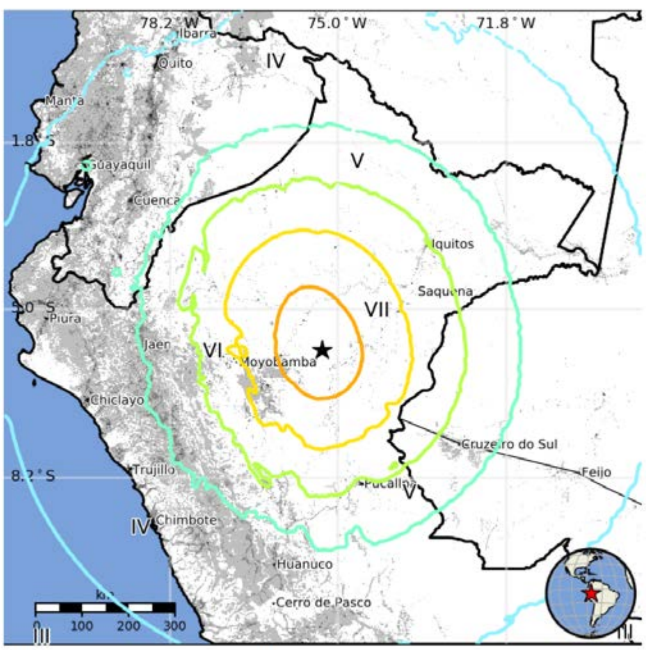
Figure 6.3. Example of collapse of non-engineered adobe construction in Perú as a result of the 2007 Pisco earthquake (Source: EERI Housing encyclopedia).

7. Estimated Population Exposed

PAGER which is a product of the USGS produces automatic reports on estimates of the possible impacts of large earthquakes by combining information from the spatial distribution of population and using isoseismals based on modified Mercalli intensity (MMI). This section discusses the population exposure. Figure 7.1 shows the isoseismals estimated for this earthquake. The earthquake was more intensely felt in Peru, with the highest estimated MMI of VIII. Strong shaking corresponding to MMI's of IV and V were also estimated for Ecuador, Colombia and Brazil. Figure 7.2 shows the number of people exposed to each shaking intensity as reported by the USGS. Because the earthquake occurred in a sparsely populated area, the largest shaking intensity (VIII) only affected around 160,000 people. This number of people is relatively low compared to the populations in the largest cities of Peru, Ecuador, and Colombia, which have millions of people.

Table.1 shows the closest cities to the epicenter with significant population exposed to different shaking intensities ranging from light to severe. As mentioned earlier, the cities with MMI of VIII have relatively small populations. Yurimaguas is the largest city that experienced an MMI of VIII. For comparison purposes, Table 7.2 lists the number of people in the ten largest cities in Peru. The distance to the earthquake epicenter from each of these cities is also included.

Estimated Population Exposure to Earthquake Shaking



Population per ~1 sq. km. from LandScan

MMI	Shaking	Population
I	Not Felt	0 k*
II-III	Weak	2,241 k*
IV	Light	23,068 k
V	Moderate	4,640 k
VI	Strong	727 k
VII	Very Strong	591 k
VIII	Severe	159 k
IX	Violent	0 k
X	Extreme	0 k

*Estimated exposure only includes population within map area (k = x1,000)

Figure 7.1. Isoseismals (curves of equal MMI) estimated for the 2019 Lagunas earthquake (USGS, 2019).

Selected Cities Exposed

☐ Show All Cities

MMI	City	Population
VIII	Lagunas	9 k
VIII	Santa Cruz	0 k
VIII	Shucushuyacu	0 k
VIII	Navarro	0 k
VIII	Pelejo	0 k
VIII	Yurimaguas	42 k
V	Iquitos	438 k
V	Trujillo	747 k
V	Guayaquil	1,952 k
IV	Chiclayo	577 k
IV	Quito	1,400 k

From GeoNames Database of Cities with 1,000 or more residents (k = x1,000)

Figure 7.2. Number of people exposed to different earthquake shaking intensities (MMI) in selected cities as a result of the earthquake (USGS, 2019).

Table 7.1. Closest cities to the epicenter with significant population exposed to different shaking intensities (MMI) as reported by USGS (population data from Wikipedia commons).

City	Country	MMI	Population (Thousands)	Epi D [km]
Lagunas	Peru	VIII	9	70
Yurimaguas	Peru	VIII	63	92
Tarapoto	Peru	VI	180	142
Requena	Peru	VII	25	180
Moyobamba	Peru	VII	50	187
Rioja	Peru	VII	90	209
Juanjui	Peru	VI	54	220
Chachapoyas	Peru	V	32	290
Iquitos	Peru	V	887	320
Cruzeiro do Sul	Brazil	V	80	355
Huamachuco	Peru	V	67	378
Jaen	Peru	V	114	386
Cajamarca	Peru	V	201	387
Tingo Maria	Peru	V	47	396
Huanuco	Peru	V	197	468
Loja	Ecuador	V	180	478
Trujillo	Peru	V	747	485
Chiclayo	Peru	IV	553	517
Cuenca	Ecuador	V	277	521
Tabatinga	Brazil	IV	63	620
Tumbes	Peru	IV	97	620
Guayaquil	Ecuador	V	2291	651
Quito	Ecuador	IV	1619	710

Table 7.2. Largest cities in Perú, and their distance to the earthquake epicenter.

Rank	City	Population	Latitude	Longitude	Epi D [km]
1	Lima	9,562,280	-12.0500	-77.0333	721
2	Arequipa	1,008,290	-16.3989	-71.5350	1248
3	Trujillo	919,899	-8.1160	-79.0300	486
4	Chiclayo	552,508	-6.7714	-79.8409	513
5	Piura	473,025	-5.1783	-80.6549	597
6	Huancayo	456,250	-12.0651	-75.2049	697
7	Cusco	428,450	-13.5226	-71.9673	933
8	Chimbote	381,513	-9.0853	-78.5783	514
9	Iquitos	377,609	-3.7491	-73.2538	321
10	Pucallpa	326,040	-8.3929	-74.5826	299

8. Estimated Loss of Life and Injuries

The PAGER (Prompt Assessment of Global Earthquakes for Response) product of the USGS is an automated system that produces content concerning the estimated impact of significant earthquakes around the world, informing emergency responders, government and aid agencies, and the media of the scope of the potential disaster. PAGER rapidly assesses earthquake impacts by comparing the population exposed to each level of shaking intensity with models of economic and fatality losses based on past earthquakes in each country or region of the world (USGS, 2019).

PAGER produces rough estimates of the probability density functions of the number of fatalities and of economic losses in U.S. dollars. More specifically, these approximate probability density functions provide estimates of the probabilities of the order of magnitude of the number of fatalities and economic losses by providing probabilities within specific ranges each varying an order of magnitude from the previous one. of shaking-related fatalities in this event was projected as relatively low according to the USGS (Fig. 8.1a) compared to previous earthquakes with similar magnitude. Such low projections stem from a combination of the relatively large depth of this event (110 km) relative to the depth of the more common interplate earthquake along the coast and the relatively small population that was exposed to strong shaking. USGS estimated that there was approximately 80% that the number of fatalities would be between 10 and 1,000. They estimated only a 10% probability of the fatalities being smaller than 10. It should be noted that these estimate are typically characterized by very large variabilities given the important uncertainties involved in the estimation of the number of fatalities. The median, mean, and standard deviation of the PAGER fatality predictions computed by recovering the parameters of a lognormal distribution from their probability densities (Jaiswal and Wald, 2010) are 93, 436, and 1237, respectively. By the second day after the earthquake, official reports by the Peruvian Emergency Operations Center (Centro de Operaciones de Emergencia Nacional - COEN) said that the earthquake caused only two reported fatalities in Cajamarca and fifteen people injured (COEN Perú, 2019). Thus, the PAGER fatality mean and median were significantly larger than the actual number of fatalities.

Similarly, PAGER estimated economic losses were projected to be relatively small (Fig. 8.1b) relative to the economy of Perú. PAGER median, mean, and standard deviation of the loss inferred from the approximate probability density function were estimated to be $382M, $ 9,324M, and $ 138,202M, respectively. The GDP in Perú is $211B and the GDP-per-capita is $6.5k, approximately 9 times smaller than the GDP-per-capita in the U.S. Thus, the median and mean are 0.2% and 4.4% of the Peruvian GDP (for reference, the U.S. GDP is almost 90 times larger than the Peruvian GDP). It should be noted that these economic loss estimates are characterized by even larger variabilities than those in their estimates of the number of fatalities. Multiple damage to roads, buildings, schools, and hospitals have been reported, but to date, no official report on the total economic losses caused by this earthquake has been issued. Past events with this alert level have required a regional or national-level response.

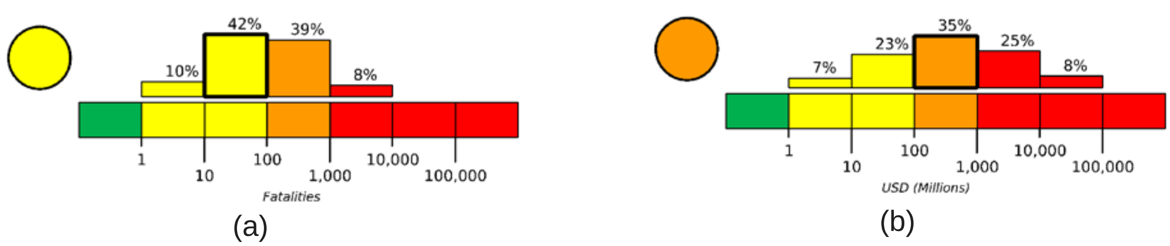


Figure 8.1. PAGER Estimated probability of (a) fatalities and (b) economic losses for the May 26, 2019 Lagunas, Perú Earthquake (USGS, 2019)

9. Impacts

9.1 Geotechnical damage

Figures 9.1 to 9.45 show several cases of geotechnical damage caused by the May 26th Lagunas earthquake. This event caused several cases of ground failure (Figures 9.1 to 9.5), landslides (Figures 9.6 to 9.8, 9.15 to 9.17, 9.33 to 9.37, and 9.39), lateral spreading (Figures 9.9 to 9.14, 9.25, 9.38, and 9.40 to 9.43), liquefaction (9.18 to 9.24, 9.44 and 9.45), and apparent combined liquefaction and lateral spreading (9.26 to 9.32).

Figure 9.1. Ground failure inside family house in Alto Amazonas, Loreto (Source: AFP [3]).

Figure 9.2. Cajabamba-Cajamarca road, close to Huañiamba (COEN, 2019).

Figure 9.3. Cajabamba-Cajamarca road, close to Huañiamba (COEN, 2019).

Figure 9.4. Cajabamba-Cajamarca, close to Huañiamba (COEN, 2019).

Figure 9.5. Road connecting Cajamarca, Huanuco and La Libertad (Source: Cuarto Poder, TV News).

Figure 9.6. Road connecting Cajamarca, Huanuco and La Libertad (Source: Cuarto Poder, TV News).

Figure 9.7. Landslide at the Gualaceo-Sigsig highway at the Province of Azuay (Source: Diario El Universo [1]).

Figure 9.8. An aerial view of a landslide near Yurimaguas in the Amazon region of Peru (Jourdan et al. 2019).

Figure 9.9. Lateral spreading along the Huallaga river at the Santa Gema near Yurimaguas in the Amazon region of Peru (Jourdan et al. 2019).

Figure 9.10. Lateral spreading along the Huallaga river at the Santa Gema near Yurimaguas in the Amazon region of Peru (Jourdan et al. 2019).

Figure 9.11. Lateral spreading along the Huallaga river at the Santa Gema near Yurimaguas in the Amazon region of Peru, (Jourdan et al. 2019).

Figure 9.12. Lateral spreading along the Huallaga river at the Santa Gema near Yurimaguas in the Amazon region of Peru, (Jourdan et al. 2019).

Figure 9.13. Lateral spreading along the Huallaga river at the Santa Gema near Yurimaguas in the Amazon region of Peru, (Jourdan et al. 2019).

Figure 9.14. Lateral spreading along the Huallaga river at the Santa Gema near Yurimaguas in the Amazon region of Peru, (Jourdan et al. 2019).

Figure 9.15. Landslide/rockfall-induced damage to the highway between Tarapoto and Yurimaguas (Holguin, 2019).

Figure 9.16. Damaged highway Tarapoto -Yurimaguas (Holguin, 2019).

Figure 9.17. Rock slides, near Yurimaguas City, Loreto Region (Holguin, 2019).

Figure 9.18. Liquefaction ejecta in district of Lagunas in Alto Amazonas, 145 km away from epicenter Loreto Region, (Source: Perú 21).

Figure 9.19. Liquefaction ejecta under a house built on wooden piles in district of Lagunas in Alto Amazonas, 145 km away from epicenter, Loreto Region. (Source: Perú 21).

Figure 9.20. Liquefaction at the Sauce district and Caserio 2 de Mayo in San Martin. (Source: Rotafono [2]).

Figure 9.21. Damage to a power pole and electrical transformer caused by liquefaction at the Sauce district and Caserio 2 de Mayo in San Martin. (Source: Rotafono [2]).

Figure 9.22. Collapse of a power pole and electrical transformer caused by liquefaction-induced failure of its footing foundation at the Sauce district and Caserio 2 de Mayo in San Martin. (Source: Rotafono [2]).

Figure 9.23. Liquefaction ejecta in El Sauce Resort, Tarapoto. (Source: Rotafono [2]).

Figure 9.24. Liquefaction ejecta in El Sauce Resort, Tarapoto (Source: Rotafono [2]).

Figure 9.25. Failure of the slab-on-grade at El Sauce Resort, Tarapoto (Source: Rotafono [2]).

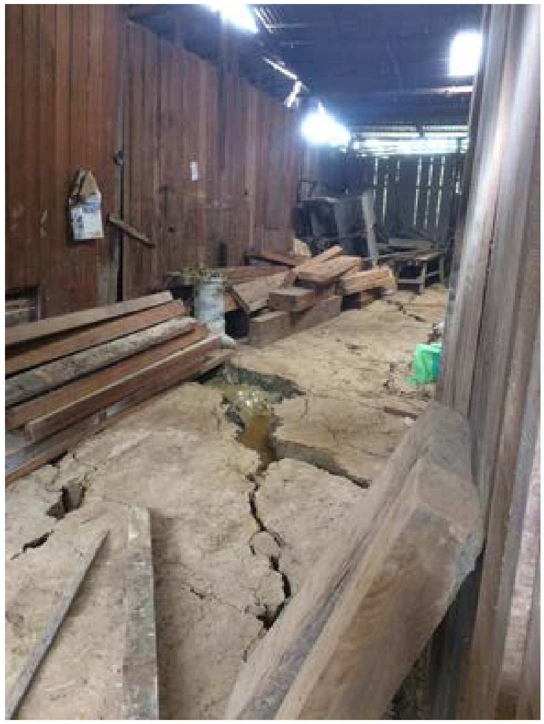


Figure 9.26. Seismically-induced ground damage due to apparent liquefaction and lateral spreading at El Sauce District (Source: Ministerio de Vivienda del Perú - Photo by Miguel Estrada).

Figure 9.27. Seismically-induced ground damage due to apparent liquefaction and lateral spreading at El Sauce District (Source: Ministerio de Vivienda del Perú - Photo by Miguel Estrada).

Figure 9.28. Seismically-induced ground damage due to liquefaction and lateral spreading at El Sauce District (Source: Ministerio de Vivienda del Perú - Photo by Miguel Estrada).

Figure 9.29. Seismically-induced ground damage at El Sauce District (Source: Ministerio de Vivienda del Perú - Photo by Miguel Estrada).

Figure 9.30. Seismically-induced ground damage due to liquefaction and lateral spreading at El Sauce District (Source: Ministerio de Vivienda del Perú - Photo by Miguel Estrada).

Figure 9.31. Seismically-induced ground damage due to apparent liquefaction and lateral spreading at El Sauce District (Source: Ministerio de Vivienda del Perú - Photo by Miguel Estrada).

Figure 9.32. Seismically-induced ground damage at El Sauce District (Source: Ministerio de Vivienda del Perú - Photo by Miguel Estrada).

Figure 9.33. Yurimaguas-Tarapoto road, hill landslides(Source: @govanniacate via Twitter).

Figure 9.34. Yurimaguas-Tarapoto road, hill landslides (Source: @govanniacate via Twitter).

Figure 9.35. Yurimaguas-Tarapoto road, hill landslides (Source: @govanniacate via Twitter).

Figure 9.36. Landslides at the Leymebamba-Chachapoyas road, Ubillon sector, km 272+00, Amazonas (COEN, 2019).

Figure 9.37. Landslides at the Leymebamba-Chachapoyas road, Ubillon sector, km 272+00, Amazonas (COEN, 2019).

Figure 9.38. Huallaga pier at Lagunas with apparent lateral spreading effects (Source: @govanniacate via Twitter).

Figure 9.39. Rockfall at 2 de Mayo village (located at 1.5 hours from Tarapoto, Sauce district) (Reategui and Mora, 2019).

Figure 9.40. Apparent lateral spreading damage in buildings at the 2 de Mayo village, Yurimaguas. (Reategui and Mora, 2019).

Figure 9.41. Severe damage in residential construction caused by ground deformations at the 2 de Mayo village, Yurimaguas (Reategui and Mora, 2019).

Figure 9.42. Apparent lateral spreading damage at the ground floor inside of a building at the 2 de Mayo village, Yurimaguas (Reategui and Mora, 2019).

Figure 9.43. Apparent lateral spreading damage in buildings at the 2 de Mayo village, Yurimaguas (Reategui and Mora, 2019).

Figure 9.44. Apparent liquefaction-induced effects in buildings located at the 2 de mayo village, Yurimaguas (Reategui and Mora, 2019).

Figure 9.45. Failure of a wharf structure along the Huallaga river near Yurimaguas (Reategui and Mora, 2019).

9.2 Buildings

9.2.1 Residential buildings

Consistent with post-earthquake field observations from past Peruvian earthquakes, and other earthquake-prone regions in developing countries, housing dwellings built with adobe suffered severe damage (Figure 9.46). Typical failure modes observed in the dwellings included vertical cracking at the corners of the house, which typically then leads to out-of-plane failures of the adobe walls. Traditionally, adobe walls do not have any type of vertical and horizontal reinforcement and have extremely low shear and lateral deformation capacity. Another structural deficiency is that roofs usually support heavy clay tiles that are prone to collapse as shown in Figures 9.47 and 9.48. Some housing dwellings in the affected region were built using hollow clay brick masonry walls, which also suffered structural damage. Some of this damage was produced by diagonal tension cracking which in some cases lead to out-of-plane failure of the walls as shown in Figure 9.49. In some cases collapse of corner adobe was observed at dwellings and buildings as shown in Figure 50 and 51. Figure 9.52 shows debris caused by the collapse of a parapet in a corner two-story adobe building in Yurimaguas City.

At the time of writing this report, there were very few cases of damage in reinforced concrete buildings. One exception is shown in Figure 9.53 which displays severe structural damage due to shear failure in relatively short and poorly detailed reinforced concrete columns.

Figure 9.46. Collapse of old-housing dwelling built of adobe brick units in Huamachuco (Source: Diario La República [4]).

Figure 9.47. Collapse of old-housing dwelling built of adobe brick units in Huamachuco (Source: Diario La República [4]).

Figure 9.48. Collapsed roof structure in, Yurimaguas City, Loreto Region (Holguin, 2019 Source: Peruvian Fire-Department [7]).

Figure 9.49. Out-of-plane failure of an interior hollow-clay brick masonry wall in Alto Amazonas, Loreto (Source: AFP [3]).

Figure 9.50. Damaged to adobe building in Alto Amazonas, Loreto (Holguin, 2019).

Figure 9.51. Partial collapse of a two-story adobe building in Yurimaguas, Perú (Holguin, 2019).

Figure 9.52. Partial collapse of the same two-story adobe building in Yurimaguas City (COEN, 2019).


Figure 9.53. Shear failure in short foundation columns of a reinforced concrete building (Source: Rotafono [2]).

9.2.2 Commercial buildings

The strong earthquake also affected commercial buildings. For instance, a two-story corner building built of hollow-clay masonry bricks suffered damage as shown in Figure 9.54. The cracking pattern indicates that the out-of-plane failure of this masonry wall was likely preceded by diagonal tension cracking in the masonry wall.

Figure 9.54. Out-of-plane failure of a masonry infill wall in a commercial building located in Yurimaguas (Source: AFP [3]).

9.2.3 Religious buildings

The earthquake resulted in the collapse of 5 churches and produced damage in 15 other churches. Figures 9.55 and 9.56 show part of a heritage church bell tower that collapsed in the town of Nambacola in the province of Loja. Nambacola is located at 56 km to the southwest of Loja city, the capital of the province of Loja. Loja city is located about 490 km from the epicenter. The church presents some cracking, and the bells that dated from 1901 were destroyed when the bell tower of the church collapsed. This structure was registered as part of the Cultural Heritage since 2015.

Figure 9.55. Bell tower of a church collapsed in Loja, Ecuador, at 490 km away from the epicenter (Trujillo, 2019).

Figure 9.56. A heritage church bell tower that collapsed in the town of Loja, Ecuador (Cueva, 2019).

Figure 9.57. Out-of-plane collapse of a masonry wall at a church in Santa Cruz, Alto Amazonas province, in the Loreto region (Source: Rotafono [2]).

Figure 9.58. Out-of-plane collapse of a masonry wall at a church in Santa Cruz, Alto Amazonas province, in the Loreto region (Source: Rotafono [2]).

Figure 9.59. Diagonal cracking in the facade of a church after the earthquake at Alto Amazonas province, in the Loreto region (Source: Rotafono [2]).

9.2.4 Healthcare facilities

The Peruvian Ministry of Healthcare reported that 52 health care facilities experienced some level of damage as a consequence of this seismic event. Table 9.1 summarize the number of affected healthcare facilities by region and province, while Table 9.2 reports the particular healthcare facility and a description of the damage surveyed as reported by the Ministry of Health (MINSA by its initials in Spanish). Six of the 52 affected healthcare facilities were hospitals that are out of service due to this event.

Table 9.1. Summary of affected hospitals in Peru. Left: Number of hospital damaged by region. Right: Number of hospitals damaged by province. (Source: Espacios de Monitoreo de Emergencias y Desastres (EMED), Ministerio de Salud, Perú.)

Regiones	Cuenta de REGIÓN
ÁNCASH	1
CAJAMARC	20
HUANUCO	1
LA LIBERTA	13
LORETO	14
PIURA	2
SAN MARTÍ	1
(en blanco)	
Total genera	52

# EESS afectados por provincia	
ALTO AMAZONAS	9
CUTERVO	5
JAEN	5
TRUJILLO	5
MAYNAS	3
SAN MIGUEL	3
VIRU	3
CAJABAMBA	2
OTUZCO	2
AIJA	1
BOLIVAR	1
DATEM DEL MARAÑÓN	1
GRAN CHIMU	1
HUALGAYOC	1
HUAMALIES	1
HUANCABAMBA	1
LORETO	1
PATAZ	1
PIURA	1
SAN IGNACIO	1
SAN MARCOS	1
SAN MARTÍN	1
SAN PABLO	1
SANTA CRUZ	1
Total general	52

Table 9.2. PART I. Detailed list of affected hospitals including location (region, province, and district), importance level, type of damage, current situation (updated May 28, 2019), and current functional state. Source: Espacios de Monitoreo de Emergencias y Desastres (EMED), Ministerio de Salud, Perú.

N°	REGIÓN	PROVINCIA	DISTRITO	IPRESS	NIVEL	DAÑO	SITUACIÓN	
							AFECTADO OPERATIVO	AFECTADO INOPERATIVO
1		ALTO AMAZONAS	YURIMAGUAS	Hospital Santa Gema de Yurimaguas	II-1	Fisuras en las paredes del Servicio de Cirugla.	X	
2		MAYNAS	PUNCHANA	Hospital Regional de Loreto "Felipe Santiago Arriola Iglesias"	III-1	Rajaduras de las paredes de los servicios de Ginecologia, cirugia, caidas de balones oxigeno.	X	
3		MAYNAS	IQUITOS	Hospital Iquitos "Cesar Garayar Garcia"	II-2	Rajadura de las paredes los servicios Centro quirúrgico, área de recuperación, Gineco obstetricia, cortocircuito en el área de farmacia y pediatria, ruptura de 02 manometros de balones de Oxigeno del área de Neonatologia, cirugia UVI.	X	
4		ALTO AMAZONAS	BALSAPUERTO	P.S Progreso de Balsapuerto	I-1	Rajadura de paredes	X	
5		ALTO AMAZONAS	SANTA CRUZ	P.S. Lago Naranjal	I-1	Rajadura de paredes	X	
6	LORETO	LORETO	NAUTA	CAP II Nauta en Loreto - EsSalud	I-3	Rajadura de paredes	X	
7		ALTO AMAZONAS	LAGUNAS	C.S. Lagunas	I-4	Afectación de techo, cielo raso y caidas al suelo de los medicamentos de las farmacias.		X
8		ALTO AMAZONAS	SANTA CRUZ	P.S. Huatapi del Rio Huallaga	I-1	Rajadura de paredes		X
9		ALTO AMAZONAS	YURIMAGUAS	C.S Centro Materno Infantil. Aguamiro	I-3	Rupturas, fisuras de paredes y techos		X
10		DATEM DEL MARAÑÓN	CAHUAPANAS	P.S. San Antonio De Cahuapanas	I-1	Daños estructurales, asentamiento de bases.		X
11		ALTO AMAZONAS	LAGUNAS	P.S. Pucacuro de Lagunas	I-1	Fisuras en las paredes	X	
12		ALTO AMAZONAS	LAGUNAS	P.S. Nueva Unión	I-1	Rajadura de paredes	X	
13		MAYNAS	BELÉN	P.S. 6 de octubre	I-1	Rajadura de paredes	X	
14		ALTO AMAZONAS	LAGUNAS	P.S. Nuevo Mundo	I-1	Rajadura en la parte posterior	X	
15		TRUJILLO	TRUJILLO	Hospital Belén de Trujillo	III-1	Area de UCI, pediatria	X	
16		BOLIVAR	BOLIVAR	Hospital Provincial De Bolivar	II-1	Fisura en columnas de las áreas de hospitalización, laboratorio	X	
17		PATAZ	HUAYLILLAS	P.S. Huaylillas	I-2	Area de consultono de obstetricia y SS.HH.	X	
18		OTUZCO	CHARAT	P.S. Charat	I-1	Rajadura en pared - tópico	X	
19		OTUZCO	USQUIL	P.S. Chuquizongo	I-2	Fisura en la pared del área de obstetricia	X	
20		GRAN CHIMU	CASCAS	C.S. El Molino	I-3	Área de laboratorio, enfermeria, nutrición, medicina	X	
21	LA LIBERTAD	VIRU	CHAO	C.S. Puente Chao	I-4	Fisuras en paredes de las áreas de cadena de frio y hospitalización	X	
22		VIRU	CHAO	P.S. Chorobal	I-1	Fisuras en la pared	X	
23		VIRU	VIRU	P.S. Santa Elena	I-2	Fisura leve en la pared del consultorio de TBC	X	
24		TRUJILLO	TRUJILLO	Hospital Regional Docente de Trujillo	III-1	Fisuras en paredes de la parte de afuera de los consultorios	X	
25		TRUJILLO	TRUJILLO	Instituto Regional de Oftalmologia	III-2	Fisuras en paredes del 3er, 4to y 5to piso	X	
26		TRUJILLO	TRUJILLO	C. S. M. I. El Bosque	I-4	Fisuras en PCT, hospitalización	X	
27		TRUJILLO	TRUJILLO	H.E.B. La Noria	II-1	Fisuras en alrededores de puertas	X	
28	PIURA	HUANCABAMBA	HUARMACA	P.S. Tolingas	I-1	Daños con paredes cuarteadas en todos los ambientes		X
29		PIURA	CASTILLA	P.S. Hormigueros	I-2	Daños en la paredes de los ambientes		X
30	SAN MARTÍN	SAN MARTÍN	SAUCE	C.S. Sauce	I-3	Grietas en la infraestructura	X	
31		SAN MIGUEL	NANCHOC	P.S. Carahuasi	I-1	Rajadura de paredes	X	
32		CAJAMARCA	CAJAMARCA	Hospital Simón Bolivar	II-E	Fisuras en Pared y cielo raso/ rotura de tanque de agua/ Ascensores no funcionan	X	
33		SAN IGNACIO	HURANGO	P.S. Pisaguas	I-1	Agrietamiento en pisos y paredes , cobertura afectada	X	

Table 9.2. PART II. Detailed list of affected healthcare facilities including location (region, province, and district), facility name, importance level, type of damage, current situation (updated May 28, 2019), and current functional state. Source: Espacios de Monitoreo de Emergencias y Desastres (EMED), Ministerio de Salud, Perú.

28-05-19

N°	REGIÓN	PROVINCIA	DISTRITO	IPRESS	NIVEL	DAÑO	SITUACIÓN	
							AFECTADO OPERATIVO	AFECTADO INOPERATIVO
34	CAJAMARCA	JAEN	JAEN	P.S. Vista Alegre	I-1	Se han producido rajaduras y agrietamientos en pisos, veredas, paredes, bases y cobertura del techo, se trata de una construcción de dos pisos con material adobe, primer nivel es un sótano para almacén y en el segundo nivel funcionan los ambientes de farmacia, sala de espera, área niño, área materno y cadena de frio, todos ellos acondicionados con triplay.	X	
35		CAJABAMBA	CONDEBAMBA	Huañimbe	I-1	Servicio de farmacia afectado en cielo razo	X	
36		JAEN	LA ESPERANZA	P.S. La Esperanza	I-2	Agrietamiento en pisos y paredes	X	
37		SAN MIGUEL	AGUA BLANCA	Agua blanca	I-1	Agrietamiento en los ambientes de tópico y área materno	X	
38		JAEN	SAN FELIPE	C.S. San Felipe	I-3	Agrietamiento en las paredes en los ambientes de farmacia , sala de espera	X	
39		JAEN	SAN FELIPE	P.S. Piquijaca		Agrietamiento en las paredes , pisos en los ambientes de farmacia , cadena de frio y sala de espera	X	
40		JAEN	JAEN	P.S. Tabacal	I-1	Rajadura y grietas en paredes	X	
41		CUTERVO	SANTO DOMINGO DE L	P.S. Nararanjoyacu	I-1	Agrietamiento en paredes y pisos , filtraciones en muro de contención	X	
42		CUTERVO	SANTO DOMINGO DE L	P.S. Palo Quemado	I-2	Agrietamiento en la cobertura , paredes y pisos	X	
43		CUTERVO	PIMPINGOS	P.S.Casa Blanca	I-1	Agrietamiento en pisos y paredes , afectación a la cobertura	X	
44		CUTERVO	VISTA ALEGRE	P.S. Vista Alegre de Sola	I-1	Agrietamiento en pisos derrumbes de tarrajeo en paredes , desprendimiento de cielo raso en los ambientes de farmacia , sala de espera , cadenas de frio	X	
45		CUTERVO	CUTERVO	P.S. Yatun	I-1	Agrietamiento en pisos , desprendimiento de tarrajeo en paredes	X	
46		SANTA CRUZ	CATACHE	P.S. La Congona	I-1	Agrietamiento en pisos , desprendimiento de cielo raso	X	
47		SAN PABLO	SAN BERNARDINO	P.S. San Bernardino	I-2	Agrietamiento en paredes y pisos en los ambientes de sala de espera , farmacia	X	
48		HUALGAYOC	HUALGAYOC	C.S. Huagal	I-4	Agrietamiento en paredes y pisos	X	
49		SAN MARCOS	JOSE SABOGAL	P.S. Huagal	I-1	Agrietamiento en paredes y pisos , Desprendimiento de tarrajeo	X	
50		SAN MIGUEL	SAN MIGUEL	C.S. San Miguel	I-4	Derrumbe en el ambiente de niño, agrietamiento en el ambiente de esterilización	X	
51	ÁNCASH	AIJA	Huacllan	P.S. Huacllan	I-1	Fisuras en los muros de sala de parto y almacen.	X	
52	HUANUCO	HUAMALIES	SINGA	C.S. Singa	I-3	Rajaduras en paredes y techos	X	

Fuente: EMED salud Loreto, La Libertad, Piura, San Martin, Cajamarca y Áncash

Figures 9.60 to 9.62 show the severe damage of a healthcare facility in Huatapi, near Yurimaguas. The new Santa Gemma hospital in Yurimaguas is a base-isolated structure (Figure 9.63) that had a very good performance during the earthquake except for small cracking that was observed near the Surgery department. The isolation bearing in the hospital are lead-core rubber bearing isolators which are shown in Figure 9.64.

Figure 9.60. General structural damage in a healthcare facility in Huatapi, near Yurimaguas, in the Amazon region of Perú (Jourdan el al. 2019).

Figure 9.61. General structural damage in a healthcare facility in Huatapi, near Yurimaguas, in the Amazon region of Perú (Jourdan el al. 2019).

Figure 9.62. General structural damage in a healthcare facility in Huatapi, near Yurimaguas, in the Amazon region of Perú (Jourdan el al. 2019).

Figure 9.63. Base-isolated hospital in Yurimaguas region (Courtesy of CIV Ingeniería Antisísmica).

Figure 9.64. Lead-core rubber bearing base-isolator at hospital in Yurimaguas region (Courtesy of CVI Ingeniería Antisísmica).

9.2.5 School buildings

It has been reported that 296 school buildings suffered damage, 6 are inhabitable and 5 out of them collapsed in the Province of Alto Amazonas according to the Minister of Education [8]. Furthermore, more than 500 schools suspended activities in five Peruvian regions as a result of the earthquake. For example, Figures 9.65 and 9.66 show a severely damaged school buildings in La Esperanza and Trujillo, respectively, while Figures 9.67 and 9.68 show an adobe school building damaged in the District of Cascapuy.

Figure 9.65. Structural damage in upper first story columns in a school building in La Esperanza, Perú (Source: Diario La Industria [6]).

Figure 9.66. Masonry damage in junior high school building in Trujillo, Perú (Source: Diario La Industria [6]).

Figure 9.67. Damage in an two-story adobe school building in Cascapuy, Perú (Source: Diario La República [4]).

Figure 9.68. Damage in an adobe school building in Cascapuy, Perú (Source: Diario La República [4]).

9.3 Lifelines

It was reported that the bridge between Yurimaguas and Tarapoto (Puente Shimbillo) suffered cracking in the asphalt surface (Figure 9.69). In the City of El Pangui, Zamora Chinchipe province in Ecuador, it was reported that the bridge that crosses the Zamora river suffered severe cracking at the bents (Figures 9.70 to 9.72). A vertical displacement of about 7 cm was measured after inspection of the bridge. A recently built international small container port in Yurimaguas on the Huallaga River, did not suffered any damage and it remained fully operational after the earthquake Figure 9.73.The port structure consists of precast reinforced concrete (RC) beams supported by steel tube piles as shown in Figures 9.74 and 9.75. The superstructure consists of RC precast beams supporting precast slabs, as shown in Figure 9.76, prior to the pouring of the concrete topping. The precast slabs have welded steel trusses so they are self-supported, including the “in situ” concrete weight and construction loads.

Figure 9.69. Bridge between Yurimaguas and Tarapoto (Puente Shimbillo) which suffered minor damaged after the earthquake [5].

Figure 9.70. Overall view of the bridge that crosses the Zamora river in Zamora Chinchipe province, Ecuador (Source:Bomberos El Pangui [7]).

Figure 9.71. Concrete spalling near the one of the supports of the bridge that crosses the Zamora river in Zamora Chinchipe province, Ecuador (Source: Bomberos El Pangui [7]).

Figure 9.72. Shear cracking at the base of one of the supports of the bridge that crosses the Zamora river in Zamora Chinchipe province, Ecuador (Source: Bomberos El Pangui [7]).

Figure 9.73. Three dimensional rendering of the new international container port in Yurimaguas on the Huallaga River. (Source: Postensa SAC. Dr. Luis Bozzo).

Figure 9.74. Overview of the port of Yurimaguas during construction. (Source: Postensa SAC. Dr. Luis Bozzo).

Figure 9.75. Overview of the port of Yurimaguas during construction (Source: Postensa SAC. Dr. Luis Bozzo).

Figure 9.76. Port of Yurimaguas during construction (Source: Postensa SAC. Dr. Luis Bozzo).

9.4 Non structural damage

This event caused significant damage to nonstructural elements such as infill walls, partition walls (usually built of masonry), and various types of building contents. For example, Figure 9.77 shows severe damage to masonry walls in a healthcare facility. As shown in Figure 9.78 in many cases cracking in the walls was accompanied by plaster spalling. In other cases, building contents including medicines placed on shelves toppled by the high lateral accelerations as shown in Figure 9.79, while Figure 9.80 displays medicine contents overturned by the high lateral accelerations.

Figure 9.77. Severe damage in a masonry win a healthcare facility near Yurimaguas in the Amazon region of Perú (Jourdan et al. 2019).

Figure 9.78. Plaster spalling and wall cracking in Lagunas, Loreto (Source: Rotafono [2]).

Figure 9.79. Medicine contents overturned by ground motions at Huatapi, from Capelo district, Requena province (Loreto) (Source: Rotafono [2]).

Figure 9.80. Medicine contents overturned by ground motions at Huatapi, from Capelo district, Requena province (Loreto) (Source: Rotafono [2]).

9.5 Social Impacts

As of May 30th (14:30 local time), the National Emergency Operations Center (COEN, by its initials in Spanish) reported 2 casualties and 17 injured inhabitants as a consequence of the earthquake, and 1,634 affected families, of which 720 were forced to flee their homes (COEN, 2019b). Additionally, it was reported 1,633 affected housing dwellings, of which 716 were judged to be uninhabitable and 6 of them collapsed. Finally, COEN reported 296 affected school buildings, counting 6 uninhabitable school buildings, 40 affected healthcare facilities, 6 in an uninhabitable state. Similarly, it was reported that there were 5 collapsed religious buildings, 15 affected religious buildings, and 21 affected commercial buildings. In terms of civil infrastructure, it was reported that there was the collapse of one bridge, 5 affected pedestrian bridges, and 54 km of affected highway roads. The following tables report in detail the statistics by District, Region, and Department compiled by COEN (2019b).

Actualizado al 30 de mayo de 2019, 14:30 horas

UBICACIÓN	VIDA Y SALUD				VIVIENDAS Y LOCALES PUBLICOS									
	FAMILIAS DAMNIFICADAS	FAMILIAS AFECTADAS	FALLECIDOS	HERIDOS	VIVIENDAS DESTRUIDAS	VIVIENDAS INHABITABLES	VIVIENDAS AFECTADAS	INSTITUCION EDUCATIVA AFECTADA	INSTITUCION EDUCATIVA INHABITABLE	CENTRO DE SALUD INHABITABLE	CENTRO DE SALUD AFECTADO	LOCALES PÚBLICOS AFECTADOS (***)	TEMPLOS DESTRUIDOS	TEMPLOS AFECTADOS
TOTAL	**720**	**1,634**	**2**	**17**	**6**	**716**	**1,633**	**296**	**6**	**6**	**40**	**21**	**5**	**15**
DPTO. LORETO	**158**	**671**		**13**		**158**	**671**	**77**	**6**	**6**	**23**	**6**	**3**	**1**
PROV.ALTO AMAZONAS	51	588		11		51	588	52	4	6	11	1	1	1
DIST. YURIMAGUAS	19	235		9		19	235	43		1	3	1		
DIST. LAGUNAS	12	260		2		12	260	8	3	1	4			
DIST. BALSAPUERTO	3	17				3	17	1		3	1			
DIST. JEBEROS	6	37				6	37						1	1
DIST. TENIENTE CESAR LOPEZ ROJAS	5	17				5	17				1			
DIST. SANTA CRUZ	6	22				6	22		1	1	2			
PROV, MARISCAL CASTILLA								1						
DIST. PEBAS								1						
PROV.LORETO	3	37				3	37	9			1		2	
DIST. PARINARI								3						
DIST. URARINAS								1						
DIST. NAUTA	3	37				3	37	5			1		2	
PROV.MAYNAS		3					3	10			5	3		
DIST. IQUITOS		2					2	3			2	3		
DIST. SAN JUAN BAUTISTA								1						
DIST. PUNCHANA								1			1			
DIST. INDIANA		1					1				1			
DIST. BELEN								5			1			
PROV. DATEM DEL MARAÑON	1	37				1	37	1			2			
DIST. PASTAZA		25					25							
DIST. BARRANCA SAN LORENZO	1	12				1	12	1			1			
DIST. CAHUAPANAS											1			
PROV.UCAYALI	100			2		100		2	2		3			
DIST. SARAYACU									**2**		**3**			
DIST. PAMPA HERMOSA (****)	100					100								
DIST. CONTAMANA				2				2						
PROV.REQUENA	3	6				3	6	2			1	2		
DIST. PUINAHUA								1						
DIST. REQUENA	3	6				3	6	1				**1**		
DIST. YAQUERANA											**1**			
DIST. CAPELO												1		
DPTO. PIURA	**4**	**20**				**4**	**20**	**12**			**1**			
PROV. HUANCABAMBA	4	20				4	20	5			1			
DIST. HUARMACA								2			**1**			
DIST. TAMBOGRANDE	4	19				4	19							
DIST. LA ARENA		1					1							
DIST. HUANCABAMBA								1						
DIST. EL CARMEN DE LA FRONTERA								2						
PROV. SECHURA								1						
DIST. VICE								1						
PROV. MORROPON								1						
DIST. SAN JUAN DE BIGOTE								1						
PROV. AYABACA								1						
DIST. PACAIPAMPA								1						
PROV. PIURA								4						
DIST. VEINTISEIS DE OCTUBRE								1						
DIST. TAMBOGRANDE								1						
DIST. LA ARENA								1						
DIST. PIURA								1						

UBICACIÓN	VIDA Y SALUD				VIVIENDAS Y LOCALES PUBLICOS									
	FAMILIAS DAMNIFICADAS	FAMILIAS AFECTADAS	FALLECIDOS	HERIDOS	VIVIENDAS DESTRUIDAS	VIVIENDAS INHABITABLES	VIVIENDAS AFECTADAS	INSTITUCION EDUCATIVA AFECTADA	INSTITUCION EDUCATIVA INHABITABLE	CENTRO DE SALUD INHABITABLE	CENTRO DE SALUD AFECTADO	LOCALES PÚBLICOS AFECTADOS (***)	TEMPLOS DESTRUIDOS	TEMPLOS AFECTADOS
TOTAL	**720**	**1,634**	**2**	**17**	**6**	**716**	**1,633**	**296**	**6**	**6**	**40**	**21**	**5**	**15**
DPTO. JUNIN		1					1							
PROV. TARMA		1					1							
DIST. SAN PEDRO DE CAJAS		1					1							
DPTO. LA LIBERTAD	18	98	1			18	98	38			8	3		
PROV. SANCHEZ CARRION	1	2				1	2	3						
DIST. HUAMACHUCO	1	2				1	2							
DIST. SARIN								3						
PROV. SANTIAGO DE CHUCO	1	6				1	6	4						
DIST. CACHICADAN	1					1		1						
DIST. SANTIAGO DE CHUCO		6					6	3						
PROV. JULCAN								4						
DIST. JULCAN								2						
DIST. CALAMARCA								2						
PROV. GRAN CHIMU											1			
DIST. CASCAS											1			
PROV. TRUJILLO		2					2	8			1	1		
DIST. MOCHE								4						
DIST. HUANCHACO								1						
DIST. POROTO		1					1							
DIST. TRUJILLO		1					1	3			1	1		
PROV. VIRU								3			2			
DIST. CHAO								2			1			
DIST. VIRU								1			1			
PROV. OTUZCO		17					17	1			2			
DIST. CHARAT											1			
DIST. AGALLPAMPA		1					1							
DIST. LA CUESTA		8					8							
DIST. SALPO		1					1							
DIST. OTUZCO								1						
DIST. USQUIL		7					7				1			
PROV. PACASMAYO								3						
DIST.SAN JOSE								2						
DIST.PACASMAYO								1						
PROV. PATAZ	4	8	1			4	8	7			1			
DIST. ONGON		1					1	2						
DIST. HUAYO	2	5				2	5	1						
DIST. PARCOY								1						
DIST. URPAY								2						
DIST. HUANCASPATA	2	2				2	2							
DIST. TAYABAMBA								1						
DIST. PATAZ			1											
DIST. HUAYLILLAS											1			
PROV. BOLIVAR	12	63				12	63	5			1	2		
DIST. BOLIVAR		3					3				1	1		
DIST. CONDORMARCA								2						
DIST. UCHUMARCA		35					35	2				1		
DIST. BAMBAMARCA	10	25				10	25	1						
DIST. LONGOTEA	2					2								

UBICACIÓN	VIDA Y SALUD				VIVIENDAS Y LOCALES PUBLICOS									
	FAMILIAS DAMNIFICADAS	FAMILIAS AFECTADAS	FALLECIDOS	HERIDOS	VIVIENDAS DESTRUIDAS	VIVIENDAS INHABITABLES	VIVIENDAS AFECTADAS	INSTITUCION EDUCATIVA AFECTADA	INSTITUCION EDUCATIVA INHABITABLE	CENTRO DE SALUD INHABITABLE	CENTRO DE SALUD AFECTADO	LOCALES PÚBLICOS AFECTADOS (***)	TEMPLOS DESTRUIDOS	TEMPLOS AFECTADOS
TOTAL	**720**	**1,634**	**2**	**17**	**6**	**716**	**1,633**	**296**	**6**	**6**	**40**	**21**	**5**	**15**
DPTO. HUANUCO	**37**	**211**			**1**	**36**	**210**	**9**			**1**	**2**		**5**
PROV. HUANUCO	18	36			1	17	36	2			1			3
DIST. CHURUBAMBA	7					7								2
DIST. QUISQUI	3	23			1	2	23				1			
DIST. SAN PEDRO DE CHAULAN	5					5								
DIST. CHINCHAO		10					10							
DIST. HUANUCO	1	1				1	1							1
DIST. SAN PABLO DE PILLAO	2	1				2	1							
DIST. PILLCOMARCA								2						
DIST. MARGOS		1					1							
PROV. MARAÑON		10					10							
DIST. HUACRACHUCO		10					10							
PROV. HUAMALIES	9	54				9	53	4						
DIST. PUÑOS		1					1	1						
DIST. LLATA														
DIST. JIRCAN	2	4				2	4	2						
DIST. TANTAMAYO								1						
DIST. CHAVIN DE PARIACA	4	30				4	30							
DIST. MONZON	2	1				2								
DIST. MIRAFLORES	1	18				1	18							
PROV. YAROWILCA		33					33	2						
DIST. CHORAS		16					16							
DIST. CHAVINILLO								2						
DIST. APARICIO POMARES		16					16							
DIST. CAHUAC		1					1							
PROV. LAURICOCHA		1					1	1						
DIST. SAN MIGUEL DE CAURI		1					1							
DIST. JESUS								1						
PROV. AMBO														1
DIST. AMBO														1
PROV. DOS DE MAYO	9	34				9	34					2		
DIST. MARIAS		10					10					1		
DIST. RIPAN	5	6				5	6							
DIST. SHUNQUI		1					1							
DIST. CHUQUIS												1		
DIST. LA UNION	4	17				4	17							
PROV. PACHITEA		7					7							
DIST. MOLINO		7					7							
PROV. HUACAYBAMBA	1	36				1	36							1
DIST. COCHABAMBA	1	2				1	2							1
DIST. HUACAYBAMBA														
DIST. CANCHABAMBA		25					25							
DIST. PINRA		9					9							
DPTO. SAN MARTIN	**329**	**371**			**2**	**327**	**371**	**37**			**2**			
PROV. SAN MARTIN	153	145				153	145	10			1			
DIST. SAUCE	93	101				93	101	5						
DIST. CHIPURANA	2					2					1			
DIST. CHAZUTA	3	14				3	14	1						
DIST. JUAN GUERRA								1						
DIST. TARAPOTO	5					5		2						
DIST. MORALES	2	4				2	4	1						
DIST. CACATACHI	3	10				3	10							
DIST. SAN ANTONIO DE CUMBAZA	3					3								
DIST. LA BANDA DE SHILCAYO	40	14				40	14							
DIST. SHAPAJA	2	2				2	2							
PROV. PICOTA								3						
DIST. BUENOS AIRES								1						
DIST. SHAMBOYACU														
DIST. PICOTA								1						
DIST. TINGO DE PONASA								1						
PROV. MOYOBAMBA	27	31			2	25	31	3						
DIST. SORITOR								1						
DIST. JEPELACIO	1	2				1	2							
DIST. MOYOBAMBA	24	22				24	22	2						
DIST. YANTALO	2	7			2		7							
PROV. RIOJA	8	4				8	4	5						
DIST. NUEVA CAJAMARCA		1					1	1						
DIST. YORONGOS								1						
DIST. RIOJA	2					2		1						
DIST. POSIC	2	1				2	1							
DIST. PARDO MIGUEL	4	2				4	2	2						
PROV. HUALLAGA								4						
DIST. SAPOSOA								2						
DIST. SACANCHE								1						
DIST. ALTO SAPOSOA								1						
PROV. MARISCAL CACERES	1	2				1	2	5						
DIST. CAMPANILLA								2						
DIST. PAJARILLO								1						
DIST. JUANJUI	1	2				1	2	2						
PROV. BELLAVISTA	52	4				52	4	1						
DIST. SAN PABLO	37					37								
DIST. BELLAVISTA	15	4				15	4							
DIST. BAJO BIAVO								1						
PROV. LAMAS	88	185				88	185	6			1			
DIST. PINTO RECODO	32					32		1						
DIST. CAYNARACHI	12	70				12	70							
DIST. SAN ROQUE DE CUMBAZA	5	15				5	15							
DIST. BARRANQUITA	12					12		1						
DIST. RUMISAPA								1						
DIST. CUÑUMBUQUI	5	36				5	36	1						
DIST. SHANAO								1						
DIST. LAMAS	10	31				10	31	1						
DIST. TABALOSOS	12	33				12	33				1			

UBICACIÓN	VIDA Y SALUD				VIVIENDAS Y LOCALES PUBLICOS									
	FAMILIAS DAMNIFICADAS	FAMILIAS AFECTADAS	FALLECIDOS	HERIDOS	VIVIENDAS DESTRUIDAS	VIVIENDAS INHABITABLES	VIVIENDAS AFECTADAS	INSTITUCION EDUCATIVA AFECTADA	INSTITUCION EDUCATIVA INHABITABLE	CENTRO DE SALUD INHABITABLE	CENTRO DE SALUD AFECTADO	LOCALES PÚBLICOS AFECTADOS (***)	TEMPLOS DESTRUIDOS	TEMPLOS AFECTADOS
TOTAL	720	1,634	2	17	6	716	1,633	296	6	6	40	21	5	15
DPTO. AMAZONAS	26	55		2		26	55	7				2		5
PROV. CHACHAPOYAS	7	43				7	43	1				1		5
DIST. MARISCAL CASTILLA		5					5							
DIST. ASUNCION		2					2	1						
DIST. GRANADA		1					1							
DIST. MAGDALENA		2					2							1
DIST. MONTEVIDEO	4	16				4	16							
DIST. CHUQUIBAMBA		11					11					1		1
DIST. OLLEROS														1
DIST. LEVANTO														1
DIST. MOLINOPAMPA														1
DIST. BALSAS		2					2							
DIST. CHACHAPOYAS	1	1				1	1							
DIST. LA JALCA	2	3				2	3							
PROV. BONGARA								3						
DIST. JAZAN								1						
DIST. YAMBRASBAMBA								2						
PROV. RODRIGUEZ DE MENDOZA				1				2						
DIST. SAN NICOLAS				1										
DIST. MARISCAL BENAVIDES								1						
DIST. LIMABAMBA								1						
PROV. UTCUBAMBA		2					2	1						
DIST. JAMALCA														
DIST. CAJARURO		2					2	1						
PROV. LUYA	14					14						1		
DIST. SANTA CATALINA	1					1								
DIST. TINGO	1					1								
DIST. CONILA	11					11								
DIST. LUYA	1					1						1		
DIST. PROVIDENCIA														
PROV. BAGUA	5	10				5	10							
DIST. ARAMANGO	3					3								
DIST. COPALLIN	2					2								
DIST. BAGUA		10					10							
PROV. CONDORCANQUI				1										
DIST. SANTA MARIA DE NIEVA				1										
DPTO. CAJAMARCA	132		1		3	129		84			4			3
PROV. CELENDIN								3			1			
DIST. HUASMIN											1			
DIST. JOSE GALVEZ								1						
DIST. CELENDIN								2						
PROV. SAN MIGUEL								3			1			
DIST. NIEPOS								1						
DIST. CALQUIS								1						
DIST. LA FLORIDA								1						
DIST. NANCHOC											1			
PROV. CAJAMARCA								1			1			
DIST. CAJAMARCA											1			
DIST. JESUS								1						
PROV. SAN IGNACIO			1					5						
DIST. HUARANGO			1					2						
DIST. SAN IGNACIO														
DIST. LA COIPA								1						
DIST. CHIRINOS								2						
PROV. SANTA CRUZ								4						
DIST. CATACHE								2						
DIST. SANTA CRUZ								1						
DIST. ESPERANZA								1						
PROV. CUTERVO								2						
DIST. SOCOTA								2						
PROV. CONTUMAZA								1						
DIST. SAN BENITO								1						
PROV. SAN MARCOS	23				3	20		8			1			1
DIST. GREGORIO PITA	23				3	20		4			1			1
DIST. JOSE SABOGAL								4						
PROV. HUALGAYOC								19						
DIST. BAMBAMARCA								15						
DIST. HUALGAYOC								2						
DIST. CHUGUR								2						
PROV. JAEN								14						
DIST. POMAHUACA								4						
DIST. BELLAVISTA								3						
DIST. SANTA ROSA								1						
DIST. HUABAL								1						
DIST. JAEN								5						
PROV. CAJABAMBA	109					109		24						2
DIST. CAJABAMBA	109					109		11						2
DIST. CACHACHI								7						
DIST. SITACOCHA								3						
DIST. CONDEBAMBA								3		1				

UBICACIÓN	VIDA Y SALUD				VIVIENDAS Y LOCALES PUBLICOS									
	FAMILIAS DAMNIFICADAS	FAMILIAS AFECTADAS	FALLECIDOS	HERIDOS	VIVIENDAS DESTRUIDAS	VIVIENDAS INHABITABLES	VIVIENDAS AFECTADAS	INSTITUCION EDUCATIVA AFECTADA	INSTITUCION EDUCATIVA INHABITABLE	CENTRO DE SALUD INHABITABLE	CENTRO DE SALUD AFECTADO	LOCALES PÚBLICOS AFECTADOS (***)	TEMPLOS DESTRUIDOS	TEMPLOS AFECTADOS
TOTAL	**720**	**1,634**	**2**	**17**	**6**	**716**	**1,633**	**296**	**6**	**6**	**40**	**21**	**5**	**15**
DPTO. ANCASH	**12**	**58**		**2**		**14**	**58**	**20**			**1**	**4**	**2**	
PROV. SANTA														
DIST. CHIMBOTE														
PROV. BOLOGNESI	2	29				2	29					1	2	
DIST. MANGAS		25					25					1	1	
DIST. HUALLANCA	2	4				2	4						1	
PROV. SIHUAS								2				1		
DIST. SAN JUAN								1						
DIST. QUICHE								1						
DIST. HUAYLLABAMBA														
DIST. SIHUAS												1		
PROV. ANTONIO RAYMONDI								1				1		
DIST. CHINGAS												1		
DIST. ACZO								1						
PROV. HUARI	2	27				4	27							
DIST. HUARI		3					3							
DIST. ANRA		19					19							
DIST. PONTO														
DIST. HUACACHI (*)	2	5				4	5							
PROV. RECUAY								6						
DIST. TICAPAMPA								1						
DIST. HUAYLLAPAMPA								1						
DIST. RECUAY								4						
PROV. HUARAZ				1										
DIST.HUARAZ				1										
PROV. HUARMEY								3						
DIST. HUARMEY								2						
DIST. HUAYAN								1						
PROV. PALLASCA				1				1						
DIST. CONCHUCOS				1				1						
PROV. OCROS								1						
DIST. SAN PEDRO								1						
PROV. HUAYLAS		1					1							
DIST. HUALLANCA		1					1							
PROV. CASMA		1					1	2				1		
DIST. YAUTAN								1				1		
DIST. CASMA		1					1	1						
PROV. ASUNCION								1						
DIST. ACOCHACA								1						
DIST. CHACAS														
PROV. AIJA	1					1		2			1			
DIST. CORIS	1					1								
DIST. LA MERCED								1						
DIST. HUACLLAN								1			1			
PROV. POMABAMBA	7					7		1						
DIST. POMABAMBA	7					7								
DIST. PAROBAMBA								1						
DIST. HUAYLLAN														
DPTO. LAMBAYEQUE	**1**	**7**				**1**	**7**	**11**				**2**		
PROV. CHICLAYO	1	4				1	4	11				1		
DIST. CHICLAYO								2						
DIST. ETEN PUERTO								1						
DIST. PIMENTEL								1						
DIST. POMALCA		1					1							
DIST. PICSI		2					2							
DIST. CHONGOYAPE								3						
DIST. PATAPO								1						
DIST. JOSE LEONARDO ORTIZ	1	1				1	1	3				1		
PROV. FERREÑAFE		1					1							
DIST. PUEBLO NUEVO		1					1							
PROV. LAMBAYEQUE		2					2					1		
DIST. LAMBAYEQUE												1		
DIST. DE MOTUPE		2					2							
DPTO. PASCO	**3**	**142**				**3**	**142**	**1**				**2**		**1**
PROV. PASCO	1	68				1	68							1
DIST. TICLACAYAN	1	22				1	22							
DIST. PAUCARTAMBO		16					16							
DIST. HUAYLLAY		25					25							
DIST. HUACHON		5					5							1
PROV. OXAPAMPA		8					8	1				1		
DIST. CHONTABAMBA								1						
DIST. SAN FRANCISCO DE ASIS YARUSYACAN		8					8							
DIST. PALCAZU												1		
PROV. DANIEL ALCIDES CARRION	2	66				2	66					1		
DIST. YANAHUANCA														
DIST. VILCABAMBA	2	4				2	4							
DIST. TUPAC		20					20							
DIST. SANTA ANA DE TUSI		35					35							
DIST. GOYLLARISQUIZGA		5					5					1		
DIST. CHACAYAN		2					2							

Actualizado al 30 de mayo de 2019, 14:30 horas

UBICACIÓN	VIDA Y SALUD				VIVIENDAS Y LOCALES PUBLICOS									
	FAMILIAS DAMNIFICADAS	FAMILIAS AFECTADAS	FALLECIDOS	HERIDOS	VIVIENDAS DESTRUIDAS	VIVIENDAS INHABITABLES	VIVIENDAS AFECTADAS	INSTITUCION EDUCATIVA AFECTADA	INSTITUCION EDUCATIVA INHABITABLE	CENTRO DE SALUD INHABITABLE	CENTRO DE SALUD AFECTADO	LOCALES PÚBLICOS AFECTADOS (***)	TEMPLOS DESTRUIDOS	TEMPLOS AFECTADOS
TOTAL	**720**	**1,634**	**2**	**17**	**6**	**716**	**1,633**	**296**	**6**	**6**	**40**	**21**	**5**	**15**
DPTO. LORETO	158	671		13		158	671	77	6	6	23	6	3	1
DPTO. PIURA	4	20				4	20	12			1			
DPTO. JUNIN		1					1							
DPTO. LA LIBERTAD	18	98	1			18	98	38			8	3		
DPTO. HUANUCO	37	211			1	36	210	9			1	2		5
DPTO. SAN MARTIN	329	371			2	327	371	37			2			
DPTO. CAJAMARCA	132		1		3	129		84			4			3
DPTO. ANCASH	12	58		2		14	58	20			1	4	2	
DPTO. LAMBAYEQUE	1	7				1	7	11				2		
DPTO. PASCO	3	142				3	142	1				2		1

UBICACIÓN	VIAS DE COMUNICACIÓN			AGRICULTURA			SERVICIOS BASICOS		
	CARRETERA AFECTADA (Km.)	PUENTE VEHICULAR COLAPSADO (**)	PUENTE PEATONAL AFECTADO	CANAL DE RIEGO (mt)	BOCATOMA DESTRUIDO	RESERVORIO AGUA AFECTADO	ENERGIA ELECTRICA AFECTADO (%)	DESAGUE AFECTADO (%)	AGUA POTABLE AFECTADO (%)
TOTAL	**54**	**1**	**5**	**650**	**1**	**2**	**X**	**X**	**X**
DPTO. LORETO	0		1			1	x		x
DPTO. PIURA	-						-	-	-
DPTO. JUNIN	-						-	-	-
DPTO. LA LIBERTAD	0.8						-	-	-
DPTO. HUANUCO	0.2						X	-	-
DPTO. SAN MARTIN	46	1	1		1	1		X	X
DPTO. CAJAMARCA	1.6		3	600			-	-	X
DPTO. ANCASH	3			50					
DPTO. LAMBAYEQUE									
DPTO. PASCO	-						X	-	X

Nota: (*) Provincia de Huari (Viviendas abandonadas).
(**) Puente Tío Yacu.
(***) Municipalidad Distrital de Capelo.
(****) Viviendas inhabitables por peligro inminente ante deslizamiento a consecuencia del sismo.
Fuente: Centros de Operaciones de Emergencia Regionales.

UBICACIÓN	VIAS DE COMUNICACIÓN			AGRICULTURA			SERVICIOS BASICOS		
	CARRETERA AFECTADA (Km.)	PUENTE VEHICULAR COLAPSADO (**)	PUENTE PEATONAL AFECTADO	CANAL DE RIEGO (mt)	BOCATOMA DESTRUIDO	RESERVORIO AGUA AFECTADO	ENERGIA ELECTRICA AFECTADO (%)	DESAGUE AFECTADO (%)	AGUA POTABLE AFECTADO (%)
TOTAL	**54**	**1**	**5**	**650**	**1**	**2**	**X**	**X**	**X**
DPTO. LORETO	**0**		**1**			**1**	**x**		**x**
PROV.ALTO AMAZONAS	0.01		1			1	X	-	-
DIST. YURIMAGUAS			1			1	X		
DIST. LAGUNAS							X		
DIST. BALSAPUERTO							X		
DIST. JEBEROS	0.01						X		
DIST. TENIENTE CESAR LOPEZ ROJAS									
DIST. SANTA CRUZ									
PROV, MARISCAL CASTILLA									
DIST. PEBAS									
PROV.LORETO	0.03						-	-	-
DIST. PARINARI									
DIST. URARINAS									
DIST. NAUTA	0.03								
PROV.MAYNAS	-						X	-	20
DIST. IQUITOS							X		10
DIST. SAN JUAN BAUTISTA							X		10
DIST. PUNCHANA									
DIST. INDIANA									
DIST. BELEN									
PROV. DATEM DEL MARAÑON	-						-	-	-
DIST. PASTAZA									
DIST. BARRANCA SAN LORENZO									
DIST. CAHUAPANAS									
PROV.UCAYALI	0.3						-	-	-
DIST. SARAYACU	**0.3**								
DIST. PAMPA HERMOSA (****)									
DIST. CONTAMANA	0.032								
PROV.REQUENA							X		X
DIST. PUINAHUA									
DIST. REQUENA							10		**X**
DIST. YAQUERANA									
DIST. CAPELO							30		**X**
DPTO. PIURA	-						-	-	-
PROV. HUANCABAMBA	-						-	-	-
DIST. HUARMACA									
DIST. TAMBOGRANDE									
DIST. LA ARENA									
DIST. HUANCABAMBA									
DIST. EL CARMEN DE LA FRONTERA									
PROV. SECHURA	-						-	-	-
DIST. VICE									
PROV. MORROPON	-						-	-	-
DIST. SAN JUAN DE BIGOTE									
PROV. AYABACA	-						-	-	-
DIST. PACAIPAMPA									
PROV. PIURA	-						-	-	-
DIST. VEINTISEIS DE OCTUBRE									
DIST. TAMBOGRANDE									
DIST. LA ARENA									
DIST. PIURA									

UBICACIÓN	VIAS DE COMUNICACIÓN			AGRICULTURA			SERVICIOS BASICOS		
	CARRETERA AFECTADA (Km.)	PUENTE VEHICULAR COLAPSADO (**)	PUENTE PEATONAL AFECTADO	CANAL DE RIEGO (mt)	BOCATOMA DESTRUIDO	RESERVORIO AGUA AFECTADO	ENERGIA ELECTRICA AFECTADO (%)	DESAGUE AFECTADO (%)	AGUA POTABLE AFECTADO (%)
TOTAL	**54**	**1**	**5**	**650**	**1**	**2**	**X**	**X**	**X**
DPTO. JUNIN	-						-	-	-
PROV. TARMA	-						-	-	-
DIST. SAN PEDRO DE CAJAS									
DPTO. LA LIBERTAD	0.8						-	-	-
PROV. SANCHEZ CARRION	-						-	-	-
DIST. HUAMACHUCO									
DIST. SARIN									
PROV. SANTIAGO DE CHUCO	0.2						-	-	-
DIST. CACHICADAN									
DIST. SANTIAGO DE CHUCO	0.2								
PROV. JULCAN	-						-	-	-
DIST. JULCAN									
DIST. CALAMARCA									
PROV. GRAN CHIMU	-						-	-	-
DIST. CASCAS									
PROV. TRUJILLO	-						-	-	-
DIST. MOCHE									
DIST. HUANCHACO									
DIST. POROTO									
DIST. TRUJILLO									
PROV. VIRU	-						-	-	-
DIST. CHAO									
DIST. VIRU									
PROV. OTUZCO	-						-	-	-
DIST. CHARAT									
DIST. AGALLPAMPA									
DIST. LA CUESTA									
DIST. SALPO									
DIST. OTUZCO									
DIST. USQUIL									
PROV. PACASMAYO	-						-	-	-
DIST.SAN JOSE									
DIST.PACASMAYO									
PROV. PATAZ	-						-	-	-
DIST. ONGON									
DIST. HUAYO									
DIST. PARCOY									
DIST. URPAY									
DIST. HUANCASPATA									
DIST. TAYABAMBA									
DIST. PATAZ									
DIST. HUAYLILLAS									
PROV. BOLIVAR	0.6						-	-	-
DIST. BOLIVAR	0.2								
DIST. CONDORMARCA									
DIST. UCHUMARCA									
DIST. BAMBAMARCA									
DIST. LONGOTEA	0.4								

UBICACIÓN	VIAS DE COMUNICACIÓN			AGRICULTURA			SERVICIOS BASICOS		
	CARRETERA AFECTADA (Km.)	PUENTE VEHICULAR COLAPSADO (**)	PUENTE PEATONAL AFECTADO	CANAL DE RIEGO (mt)	BOCATOMA DESTRUIDO	RESERVORIO AGUA AFECTADO	ENERGIA ELECTRICA AFECTADO (%)	DESAGUE AFECTADO (%)	AGUA POTABLE AFECTADO (%)
TOTAL	**54**	**1**	**5**	**650**	**1**	**2**	**X**	**X**	**X**
DPTO. HUANUCO	0.2						X	-	-
PROV. HUANUCO	-						-	-	-
DIST. CHURUBAMBA									
DIST. QUISQUI									
DIST. SAN PEDRO DE CHAULAN									
DIST. CHINCHAO									
DIST. HUANUCO									
DIST. SAN PABLO DE PILLAO									
DIST. PILLCOMARCA									
DIST. MARGOS									
PROV. MARAÑON	-						-	-	-
DIST. HUACRACHUCO									
PROV. HUAMALIES	-						-	-	-
DIST. PUÑOS									
DIST. LLATA									
DIST. JIRCAN									
DIST. TANTAMAYO									
DIST. CHAVIN DE PARIACA									
DIST. MONZON									
DIST. MIRAFLORES									
PROV. YAROWILCA	-						-	-	-
DIST. CHORAS									
DIST. CHAVINILLO									
DIST. APARICIO POMARES									
DIST. CAHUAC									
PROV. LAURICOCHA	-						-	-	-
DIST. SAN MIGUEL DE CAURI									
DIST. JESUS									
PROV. AMBO	-						-	-	-
DIST. AMBO									
PROV. DOS DE MAYO	-						X	-	-
DIST. MARIAS									
DIST. RIPAN							X		
DIST. SHUNQUI									
DIST. CHUQUIS									
DIST. LA UNION									
PROV. PACHITEA	-						-	-	-
DIST. MOLINO									
PROV. HUACAYBAMBA	0.2						-	-	-
DIST. COCHABAMBA									
DIST. HUACAYBAMBA	0.2								
DIST. CANCHABAMBA									
DIST. PINRA									
DPTO. SAN MARTIN	46	1	1		1	1		X	X
PROV. SAN MARTIN	30						-	X	-
DIST. SAUCE								X	
DIST. CHIPURANA									
DIST. CHAZUTA	23								
DIST. JUAN GUERRA									
DIST. TARAPOTO									
DIST. MORALES									
DIST. CACATACHI									
DIST. SAN ANTONIO DE CUMBAZA									
DIST. LA BANDA DE SHILCAYO									
DIST. SHAPAJA	7								
PROV. PICOTA	-				1		-	-	-
DIST. BUENOS AIRES									
DIST. SHAMBOYACU					1				
DIST. PICOTA									
DIST. TINGO DE PONASA									
PROV. MOYOBAMBA	-						-	-	-
DIST. SORITOR									
DIST. JEPELACIO									
DIST. MOYOBAMBA									
DIST. YANTALO									
PROV. RIOJA	-		1				-	-	-
DIST. NUEVA CAJAMARCA									
DIST. YORONGOS									
DIST. RIOJA									
DIST. POSIC			1						
DIST. PARDO MIGUEL									
PROV. HUALLAGA	-						-	-	-
DIST. SAPOSOA									
DIST. SACANCHE									
DIST. ALTO SAPOSOA									
PROV. MARISCAL CACERES	-						-	-	-
DIST. CAMPANILLA									
DIST. PAJARILLO									
DIST. JUANJUI									
PROV. BELLAVISTA	-						-	-	-
DIST. SAN PABLO									
DIST. BELLAVISTA									
DIST. BAJO BIAVO									
PROV. LAMAS	16	1				1	-	-	X
DIST. PINTO RECODO	16	1				1			
DIST. CAYNARACHI									
DIST. SAN ROQUE DE CUMBAZA									
DIST. BARRANQUITA									X
DIST. RUMISAPA									
DIST. CUÑUMBUQUI									
DIST. SHANAO									
DIST. LAMAS									
DIST. TABALOSOS									

UBICACIÓN	VIAS DE COMUNICACIÓN			AGRICULTURA			SERVICIOS BASICOS		
	CARRETERA AFECTADA (Km.)	PUENTE VEHICULAR COLAPSADO (**)	PUENTE PEATONAL AFECTADO	CANAL DE RIEGO (mt)	BOCATOMA DESTRUIDO	RESERVORIO AGUA AFECTADO	ENERGIA ELECTRICA AFECTADO (%)	DESAGUE AFECTADO (%)	AGUA POTABLE AFECTADO (%)
TOTAL	**54**	**1**	**5**	**650**	**1**	**2**	**X**	**X**	**X**
DPTO. AMAZONAS	1.9						-	-	-
PROV. CHACHAPOYAS	0.6						-	-	-
DIST. MARISCAL CASTILLA									
DIST. ASUNCION									
DIST. GRANADA									
DIST. MAGDALENA									
DIST. MONTEVIDEO									
DIST. CHUQUIBAMBA									
DIST. OLLEROS									
DIST. LEVANTO									
DIST. MOLINOPAMPA									
DIST. BALSAS									
DIST. CHACHAPOYAS	0.2								
DIST. LA JALCA	0.4								
PROV. BONGARA	0.1						-	-	-
DIST. JAZAN	0.1								
DIST. YAMBRASBAMBA									
PROV. RODRIGUEZ DE MENDOZA	-						-	-	-
DIST. SAN NICOLAS									
DIST. MARISCAL BENAVIDES									
DIST. LIMABAMBA									
PROV. UTCUBAMBA	0.3						-	-	-
DIST. JAMALCA	0.3								
DIST. CAJARURO									
PROV. LUYA	0.6						-	-	-
DIST. SANTA CATALINA									
DIST. TINGO									
DIST. CONILA									
DIST. LUYA	0.6								
DIST. PROVIDENCIA									
PROV. BAGUA	0.3						-	-	-
DIST. ARAMANGO									
DIST. COPALLIN	0.3								
DIST. BAGUA									
PROV. CONDORCANQUI	-						-	-	-
DIST. SANTA MARIA DE NIEVA									
DPTO. CAJAMARCA	1.6		3	600			-	-	X
PROV. CELENDIN	-						-	-	-
DIST. HUASMIN									
DIST. JOSE GALVEZ									
DIST. CELENDIN									
PROV. SAN MIGUEL	-						-	-	-
DIST. NIEPOS									
DIST. CALQUIS									
DIST. LA FLORIDA									
DIST. NANCHOC									
PROV. CAJAMARCA	-						-	-	-
DIST. CAJAMARCA									
DIST. JESUS									
PROV. SAN IGNACIO	0.8						-	-	X
DIST. HUARANGO	0.8								
DIST. SAN IGNACIO									X
DIST. LA COIPA									
DIST. CHIRINOS									
PROV. SANTA CRUZ	-						-	-	-
DIST. CATACHE									
DIST. SANTA CRUZ									
DIST. ESPERANZA									
PROV. CUTERVO	-						-	-	-
DIST. SOCOTA									
PROV. CONTUMAZA	-						-	-	-
DIST. SAN BENITO									
PROV. SAN MARCOS	0.4		3	100			-	-	X
DIST. GREGORIO PITA	0.4		3	100					X
DIST. JOSE SABOGAL									
PROV. HUALGAYOC	-						-	-	-
DIST. BAMBAMARCA									
DIST. HUALGAYOC									
DIST. CHUGUR									
PROV. JAEN	-						-	-	-
DIST. POMAHUACA									
DIST. BELLAVISTA									
DIST. SANTA ROSA									
DIST. HUABAL									
DIST. JAEN									
PROV. CAJABAMBA	0.4			500			-	-	X
DIST. CAJABAMBA	0.1			500					X
DIST. CACHACHI									
DIST. SITACOCHA									
DIST. CONDEBAMBA	0.3								

UBICACIÓN	VIAS DE COMUNICACIÓN			AGRICULTURA			SERVICIOS BASICOS		
	CARRETERA AFECTADA (Km.)	PUENTE VEHICULAR COLAPSADO (**)	PUENTE PEATONAL AFECTADO	CANAL DE RIEGO (mt)	BOCATOMA DESTRUIDO	RESERVORIO AGUA AFECTADO	ENERGIA ELECTRICA AFECTADO (%)	DESAGUE AFECTADO (%)	AGUA POTABLE AFECTADO (%)
TOTAL	**54**	**1**	**5**	**650**	**1**	**2**	**X**	**X**	**X**
DPTO. ANCASH	3			50					
PROV. SANTA	-						X	-	-
DIST. CHIMBOTE							X		
PROV. BOLOGNESI	0								
DIST. MANGAS	0.4								X
DIST. HUALLANCA									
PROV. SIHUAS	1								
DIST. SAN JUAN									
DIST. QUICHE									
DIST. HUAYLLABAMBA	0.8								
DIST. SIHUAS									
PROV. ANTONIO RAYMONDI	0			50					
DIST. CHINGAS									
DIST. ACZO	0.3			50					
PROV. HUARI	1								
DIST. HUARI									
DIST. ANRA									
DIST. PONTO	0.8								
DIST. HUACACHI (*)	0.2						X		
PROV. RECUAY	-						-	-	-
DIST. TICAPAMPA									
DIST. HUAYLLAPAMPA									
DIST. RECUAY									
PROV. HUARAZ	-						X	-	-
DIST.HUARAZ							X		
PROV. HUARMEY									
DIST. HUARMEY							X		
DIST. HUAYAN									
PROV. PALLASCA	-						X	-	-
DIST. CONCHUCOS									
PROV. OCROS	-						X	-	-
DIST. SAN PEDRO									
PROV. HUAYLAS	-						X	-	-
DIST. HUALLANCA							X		
PROV. CASMA									
DIST. YAUTAN									
DIST. CASMA									
PROV. ASUNCION	0.2						X	-	-
DIST. ACOCHACA	0.2								
DIST. CHACAS							X		
PROV. AIJA									
DIST. CORIS									
DIST. LA MERCED									
DIST. HUACLLAN									
PROV. POMABAMBA	0.5						X	-	-
DIST. POMABAMBA	0.5						X		
DIST. PAROBAMBA									
DIST. HUAYLLAN							X		
DPTO. LAMBAYEQUE									
PROV. CHICLAYO	-						-	-	-
DIST. CHICLAYO									
DIST. ETEN PUERTO									
DIST. PIMENTEL									
DIST. POMALCA									
DIST. PICSI									
DIST. CHONGOYAPE									
DIST. PATAPO									
DIST. JOSE LEONARDO ORTIZ									
PROV. FERREÑAFE									
DIST. PUEBLO NUEVO									
PROV. LAMBAYEQUE									
DIST. LAMBAYEQUE									
DIST. DE MOTUPE									
DPTO. PASCO	-						X	-	X
PROV. PASCO	-						-	-	-
DIST. TICLACAYAN									
DIST. PAUCARTAMBO									
DIST. HUAYLLAY									
DIST. HUACHON									
PROV. OXAPAMPA	-						-	-	-
DIST. CHONTABAMBA									
DIST. SAN FRANCISCO DE ASIS YARUSYACAN									
DIST. PALCAZU									
PROV. DANIEL ALCIDES CARRION	-						X	-	X
DIST. YANAHUANCA							X		
DIST. VILCABAMBA									
DIST. TUPAC									
DIST. SANTA ANA DE TUSI									
DIST. GOYLLARISQUIZGA									
DIST. CHACAYAN									X

10. References

Abrahamson, N., Gregor, N., & Addo, K. (2016). BC Hydro ground motion prediction equations for subduction earthquakes. *Earthquake Spectra*, *32*(1), 23-44.

COEN (2019), Reporte complementario Nº1268 - 27/05/2019 / COEN-INDECI / 16:30 HORAS (Reporte Nº 07), Movimiento Sísmico de Magnitud 8.0, Lagunas - Loreto.

COEN (2019b), Informe de emergencia No. 518-30/05/2019/COEN-INDECI/14:30hrs.

CISMID–FIC–UNI Y SENCICO, (2019), *Informe de Acelerogramas del Sismo de Lagunas, Amazonas del 26 de mayo de 2019.* Centro Peruano-Japonés de Investigaciones Sísmicas y Mitigación de Desastres (CISMID) de la Facultad de Ingeniería Civil (FIC) de la Universidad Nacional de Ingeniería (UNI), pp. 9, In Spanish.

CIP–UNI (2019), *Informe especial Red Acelerográfica CIP-UNI Sismo de Lagunas-Alto Amazonas-Loreto 26 de mayo de 2019.* Colegio de Ingenieros del Perú (CIP) and Universidad Nacional de Ingeniería (UNI), pp. 9, In Spanish.

CIP-UNI, Red Acelerografica CIP, Detalles Tecnicos. Last accessed May 26, 2019. http://www.red-acelerografica-peru.com/site/page?view=caracteristicas

Converse, A.M., & Brady, AG. (1992). BAP – Basic strong-motion accelerogram processing software, Version 1.0. Open File Report No. 92-296A U.S. Geological Survey Open File Report No. 92-296A, Menlo Park.

Cueva, E., "Campanario de iglesia en parroquia lojana se derrumbo por sismo de esta madrugada, May 26, 2019" https://www.eluniverso.com/noticias/2019/05/26/nota/7348163/campanario-iglesia-parroquia-lojana-se-derrumbo-sismo-esta , In Spanish.

Elnashai, A., Alva-Hurtado, J., Pineda, O., Kwon, O. S., Moran-Yanez, L., Huaco, G., & Pluta, G. (2008). The Pisco-Chincha Earthquake of August 15 , 2007. No. 08-01.

García, D., Singh, S. K., Herráiz, M., Ordaz, M., & Pacheco, J. F. (2005). Inslab earthquakes of central Mexico: peak ground-motion parameters and response spectra. *Bulletin of the Seismological Society of America*, *95*(6), 2272-2282.

Gonzalez Fernandez, H. & Bozzo Rotondo, L. (2016). Memoria de cálculo de nuevo terminal portuario de Yurimaguas, Postensa, Lima, Perú, In Spanish.

Holguin, H., "Fotos; Sismo en Peru: casas y vias destruidas en el norte del país, May 26, 2019" https://cnnespanol.cnn.com/gallery/fotos-terremoto-peru-loreto-carreteras-bloqueadas-estructuras-colapsadas-sismo-norte-pais/, In Spanish.

Husid, R. (1969). Características de terremotos. Análisis general. *Revista IDIEM*, *8*(1), ág-21.

IG-EPN 2019. *"Informe Sísmico Especial # 12: Sismo en el Nor-Oriente Peruano"*. Instituto Geofísico de la Escuela Politécnica Nacional, In Spanish.

Jaiswal, K., & Wald, D. (2010). An empirical model for Global Earthquake fatality estimation. Earthquake Spectra, 26(4), 1017–1037.

Jourdan, A., Sherwood D., and Taj, M., “Strong quake in Peru kills one person, disrupts some oil operations, May 26, 2019” https://www.reuters.com/article/us-peru-quake/strong-earthquake-strikes-northern-peru-idUSKCN1SW06U

Loaiza, C., & Blondet, M. (2002). Housing Report - Confined masonry building. World Housing Encyclopedia - EERI.

Loaiza, C., Blondet, M., & Ottazzi, G. (2002). Housing Report - Adobe housing. World Housing Encyclopedia - EERI.

Ministerio de Vivienda (2016). Norma Tecnica E.030 “Diseño Sismorresistente”, In Spanish.

Montalva, G. A., Bastías, N., & Rodriguez-Marek, A. (2017). Ground-motion prediction equation for the Chilean subduction zone. *Bulletin of the Seismological Society of America*, *107*(2), 901-911.

Reategui, C., Mora, M., “30 fotos que muestran como quedaron las viviendas en uno de los distritos mas afectados por el terremoto, May 27, 2019” https://rpp.pe/peru/actualidad/terremoto-en-loreto-las-fotos-que-muestran-como-quedaron-las-viviendas-en-uno-de-los-distritos-mas-afectados-por-el-sismo-noticia-1199326 , In Spanish.

SGS, Servicio Geologico Colombiano, sismos sentidos, Last accessed May 26, 2019. http://sismosentido.sgc.gov.co/EvaluacionIntensidadesServlet?id_sismo=SGC2019kfoqc&metodo=verSalidas

Servicio Nacional de Gestión de Riesgos, Informe de situación No. 3 Sismo Perú 26/05/2019, In Spanish.

Trujillo, Y., “Siete heridos en Ecuador tras el sismo de magnitud 8.09 en Peru, May 26, 2019” https://www.elcomercio.com/actualidad/heridos-ecuador-sismo-peru-emergencia.html , In Spanish.

Vera-Grunauer, X. (2014). *Seismic response of a soft, high plasticity, diatomaceous naturally cemented clay deposit*. PhD thesis, Department of Civil and Environmental Engineering, University of California at Berkeley, Berkeley, California.

Vera-Grunauer, X., Nikolaou, S., Gilsanz, R., Diaz-Fanas, G., Antonaki, N., Lopez, S., Luque, R., Casares, B., Caicedo, A., Alzamora, D., Rollins, K., Wood, C., Athanasopoulos-Zekkos, A., Lyvers, G., Diaz, V., Toulkeridis, T., Morales, E., (2017). GEER-ATC Mw 7.8 Ecuador 4/16/16 Earthquake Reconnaissance Part II: Selected Geotechnical Observations, *Proceedings 16th World Conference on Earthquake Engineering*, 16WCEE 2017, Santiago, Chile, January 2017.

Villegas-Lanza, J. C., Chlieh, M., Cavalié, O., Tavera, H., Baby, P., Chire-Chira, J., & Nocquet, J.-M. (2016). Active tectonics of Peru: Heterogeneous interseismic coupling along the Nazca megathrust, rigid motion of the Peruvian Sliver, and Subandean shortening accommodation. *Journal of Geophysical Research : Solid Earth*, 1–24.

Yepes-Estrada, C., Silva, V., Valcárcel, J., Acevedo, A. B., Tarque, N., Hube, M. A., … María, H. S. (2017). Modeling the Residential Building Inventory in South America for Seismic Risk Assessment. *Earthquake Spectra*, *33*(1), 299–322.

USGS, Did You Feel It - Background information, United States Geological Survey, Last accessed May 26, 2019. https://earthquake.usgs.gov/data/dyfi/background.php

USGS, Latest Earthquakes M 8.0 - 75km SSE of Lagunas, Peru, Last accessed May 26, 2019. https://earthquake.usgs.gov/earthquakes/eventpage/us60003sc0/executive

11. Other Internet Resources Used

URL #	URL
1	https://www.eluniverso.com/noticias/2019/05/26/nota/7348139/siete-heridos-afectaciones-casas-zamora-chinchipe-sismo-epicentro
2	https://rpp.pe/peru/actualidad/terremoto-en-loreto-las-fotos-compartidas-por-oyentes-de-rpp-que-muestran-los-efectos-del-sismo-noticia-1199176
3	https://www.semana.com/mundo/galeria/imagenes-del-sismo-en-peru/617207
4	https://larepublica.pe/sociedad/1476562-imagenes-exclusivas-yurimaguas-terromoro-fotos/9?ref=photogallery
5	https://diariocorreo.pe/peru/suspenden-clases-en-511-colegios-de-las-zonas-afectadas-por-el-sismo-de-magnitud-80-889419/?ref=list_pri_5
6	http://www.laindustria.pe/imagenes/982-as-se-encuentran-los-colegios-liberteos-afectados-por-sismo-fotos
7	https://www.facebook.com/Bomberos-El-Pangui-679801482152287/?__tn__=%2Cd%2CP-R&eid=ARDrKrYHnDe5XSlcZ2UR9MAzZv4JUkDOSQpH6dC42r_uGvuygGGQ-Y9gFybLKdYIa-mvbCFZFT5zdx--
8	https://diariocorreo.pe/peru/suspenden-clases-en-mas-de-500-colegios-de-5-regiones-por-sismos-889474/?ref=list_pri_6

12. Acknowledgements

StEER gratefully acknowledges the financial support of the National Science Foundation under Award CMMI-1841667, with deep appreciation for the mentorship provided by Dr. Joy Pauschke. Any opinions, findings, and conclusions or recommendations expressed in this material are those of the authors and do not necessarily reflect the views of the National Science Foundation.

Special thanks are given to Centro Peruano-Japonés de Investigaciones Sísmicas y Mitigación de Desastres (CISMID), the Universidad Nacional de Ingeniería (UNI), Colegio de Ingenieros Civiles de Perú (CIP), Servicio Nacional de Capacitación para la Industria de la Construcción (SENCICO) for making available and disseminating information of the ground motions recorded in their networks. Efforts to install, operate, and maintain seismic instrumentation as well as to process and disseminate earthquake records by these organizations are gratefully acknowledged.

Additionally, we would like to thank Dr. Miguel Estrada Mendoza Ministro de Vivienda, Construcción y Saneamiento (Minister of Housing, Construction and Sanitation of Perú), Dr. Jorge Alva Hurtado, Rector Universidad Nacional de Ingeniería (UNI), Ing. Saúl Tito Ccoicca of the Ministry of Health (Ministerio de Salud, MINSA), Dr. Luis Bozzo Rotondo, Postensa, Perú and Prof. Walter Mera Ortíz and Ing. Angel Yagunes at Centro de Monitoreo Sísmico, (CEMSIS) of the Universidad Católica de Santiago de Guayaquil for providing some information that is included in this report.

Finally, we would like to specially thank all co-authors who helped the team leader produce this report in a short amount of time. They all volunteered many hours of work in searching, carefully documenting the source of each piece of information gathered and in helping write and produce this VAST report. Many of these hours of work of the fully bilingual (English and Spanish) team were during the three-day Memorial Day weekend and during long nights and on top of their many daily obligations. Professors Khalid Mosalam, Ian Robertson and David Roueche served as editors of the document and provided valuable support during the production of this report. The lead author sincerely thanks them for their help and the valuable time devoted to writing this effort.

13. About StEER

The National Science Foundation (NSF) awarded a 2-year EAGER grant (CMMI 1841667) to a consortium of universities to form the Structural Extreme Events Reconnaissance (StEER) Network. StEER's mission is to deepen the structural natural hazards engineering (NHE) community's capacity for reliable post-event reconnaissance by: (1) promoting community-driven standards, best practices, and training for RAPID field work; (2) coordinating official event responses in collaboration with other stakeholders and reconnaissance groups; and (3) representing structural engineering within the wider extreme events reconnaissance (EER) consortium in geotechnical engineering (GEER) and social sciences (SSEER) to foster greater potentials for truly interdisciplinary reconnaissance. StEER also works closely with the NSF-supported Natural Hazards Engineering Research Infrastructure (NHERI) RAPID facility and cyberinfrastructure Reconnaissance Portal to more effectively leverage these resources to benefit StEER missions.

StEER relies upon the engagement of the broad NHE community, including creating institutional linkages with dedicated liaisons to existing post-event communities and partnerships with other key stakeholders. While the network currently consists of the three primary nodes located at the University of Notre Dame (Coordinating Node), University of Florida (Atlantic/Gulf Regional Node), and University of California, Berkeley (Pacific Regional Node), StEER aspires to build a network of regional nodes worldwide to enable swift and high quality responses to major disasters globally.

StEER's founding organizational structure includes a governance layer comprised of core leadership with Associate Directors for the two primary hazards as well as cross-cutting areas of Assessment Technologies and Data Standards, led by the following individuals:

- **Tracy Kijewski-Correa (PI),** University of Notre Dame, serves as StEER Director responsible with overseeing the design and operationalization of the network.
- **Khalid Mosalam (co-PI),** University of California, Berkeley, serves as StEER Associate Director for Seismic Hazards, leading StEER's Pacific Regional node and serving as primary liaison to the Earthquake Engineering community.
- **David O. Prevatt (co-PI),** University of Florida, serves as StEER Associate Director for Wind Hazards, leading StEER's Atlantic/Gulf Regional node and serving as primary liaison to the Wind Engineering community.
- **Ian Robertson (co-PI),** University of Hawai'i at Manoa, serves as StEER Associate Director for Assessment Technologies, guiding StEER's development of a robust approach to damage assessment across the hazards.
- **David Roueche (co-PI),** Auburn University, serves as StEER Associate Director for Data Standards, ensuring StEER processes deliver reliable and standardized reconnaissance data.

14. StEER Event Report Library

14.1 2018 Reports

Robertson, Ian; Head, Monique; Roueche, David; Wibowo, Hartanto; Kijewski-Correa, Tracy; Mosalam, Khalid; Prevatt, David (2018-12-31), "StEER - SUNDA STRAIT TSUNAMI (INDONESIA): PRELIMINARY VIRTUAL ASSESSMENT TEAM (P-VAT) REPORT" DesignSafe-CI [publisher], Dataset, doi:10.17603/DS2Q98T [DOI: https://doi.org/10.17603/DS2Q98T]
Mosalam, Khalid; Kijewski-Correa, Tracy; Hassan, Wael; Archbold, Jorge; Marshall, Justin; Mavroeidis, George; Muin, Sifat; mulchandani, Harish; Peng, Han; Pretell Ductram, Anthony Renmin; Prevatt, David; Robertson, Ian; Roueche, David (2018-12-06), "StEER - EERI ALASKA EARTHQUAKE: PRELIMINARY VIRTUAL ASSESSMENT TEAM (P-VAT) JOINT REPORT" DesignSafe-CI [publisher], Dataset, doi:10.17603/DS2MQ38 [DOI: https://doi.org/10.17603/DS2MQ38]

Roueche, David; Cleary, John; Gurley, Kurtis; Marshall, Justin; Pinelli, Jean-Paul; Prevatt, David; Smith, Daniel; Alipour, Alice; Angeles, Karen; Davis, Brett; Gonzalez, Camila; Lenjani, Ali; mulchandani, Harish; Musetich, Matthew; Salman, Abdullahi; Kijewski-Correa, Tracy; Robertson, Ian; Mosalam, Khalid, (2018-10-25), "StEER - HURRICANE MICHAEL: FIELD ASSESSMENT TEAM 1 (FAT-1) EARLY ACCESS RECONNAISSANCE REPORT (EARR)" , DesignSafe-CI [publisher], Dataset, doi:10.17603/DS2G41M [DOI: https://ezid.cdlib.org/id/doi:10.17603/DS2G41M]

Alipour, Alice; Aly, Aly Mousaad; Davis, Brett; Gutierrez Soto, Mariantonieta; Kijewski-Correa, Tracy; Lenjani, Ali; Lichty, Benjamin; Miner, Nathan; Roueche, David; Salman, Abdullahi; Smith, Daniel; Sutley, Elaina; Mosalam, Khalid; Prevatt, David; Robertson, Ian, (2018-10-19), "STEER - HURRICANE MICHAEL: PRELIMINARY VIRTUAL ASSESSMENT TEAM (P-VAT) REPORT" , DesignSafe-CI [publisher], Dataset, doi:10.17603/DS2RH71 [DOI: https://ezid.cdlib.org/id/doi:10.17603/DS2RH71]

Hu, Fan; Robertson, Ian; Mosalam, Khalid; Gunay, Selim; Kijewski-Correa, Tracy; Peng, Han; Prevatt, David; Cohen, Jade, (2018-10-11), "StEER - 2018 HAITI EARTHQUAKE: PRELIMINARY VIRTUAL ASSESSMENT TEAM (P-VAT) REPORT" , DesignSafe-CI [publisher], Dataset, doi:10.17603/DS2Z69H [DOI: https://ezid.cdlib.org/id/doi:10.17603/DS2Z69H]

Robertson, Ian; Kijewski-Correa, Tracy; Roueche, David; Prevatt, David, (2018-10-04), "PALU EARTHQUAKE AND TSUNAMI, SUWALESI, INDONESIA PRELIMINARY VIRTUAL ASSESSMENT TEAM (PVAT) REPORT" , DesignSafe-CI [publisher], Dataset, doi:10.17603/DS2XD5S [DOI: https://ezid.cdlib.org/id/doi:10.17603/DS2XD5S]

Barnes, Robert; Lytle, Blake; Rogers, Spencer; Pei, Weichiang; Kijewski-Correa, Tracy; Gonzalez, Camila; u, Fan; Musetich, Matthew; Peng, Han; Prevatt, David; Roueche, David; Salman,Abdullahi; Mosalam, Khalid; Robertson, Ian, (2018-09-25), "HURRICANE FLORENCE: FIELD ASSESSMENT TEAM 1 (FAT-1) EARLY ACCESS RECONNAISSANCE REPORT (EARR)", DesignSafe-CI [publisher], Dataset, doi:10.17603/DS2TT3G [DOI: https://ezid.cdlib.org/id/doi:10.17603/DS2TT3G]

14.2 2019 Reports

StEER - 3 MARCH 2019 TORNADOES IN THE SOUTHEASTERN US: FIELD ASSESSMENT TEAM EARLY ACCESS RECONNAISSANCE REPORT (EARR)
FULL CITATION PENDING DESIGN SAFE
Access immediately at https://aub.ie/prj_2265

Roueche, David; Davis, Brett; Hodges, Courtney; Rittelmeyer, Brandon; Turner, Kelly; Kijewski-Correa, Tracy; Prevatt, David; Robertson, Ian; Mosalam, Khalid (2019-01-30) , "StEER - 19 JANUARY 2019 TORNADOES IN THE SOUTHEASTERN US: FIELD ASSESSMENT TEAM EARLY ACCESS RECONNAISSANCE REPORT (EARR)", DesignSafe-CI [publisher], Dataset, doi:10.17603/ds2-eb6e-tr31 [DOI: https://doi.org/10.17603/ds2-eb6e-tr31]

Robertson, Ian; Esteban, Miguel; Stolle, Jacob; Takabatake, Tomoyuki; mulchandani, Harish; Kijewski-Correa, Tracy; Prevatt, David; Roueche, David; Mosalam, Khalid (2019-01-15), "StEER - PALU EARTHQUAKE AND TSUNAMI, SULAWESI, INDONESIA: FIELD ASSESSMENT TEAM 1 (FAT-1) EARLY ACCESS RECONNAISSANCE REPORT (EARR)", DesignSafe-CI [publisher], Dataset, doi:10.17603/DS2JD7T [DOI: https://doi.org/10.17603/DS2JD7T]