CASE STUDY - SEISMOLOGY

Earthquake Early Warning, Central America

Public Earthquake Early Warning (EEW) Systems

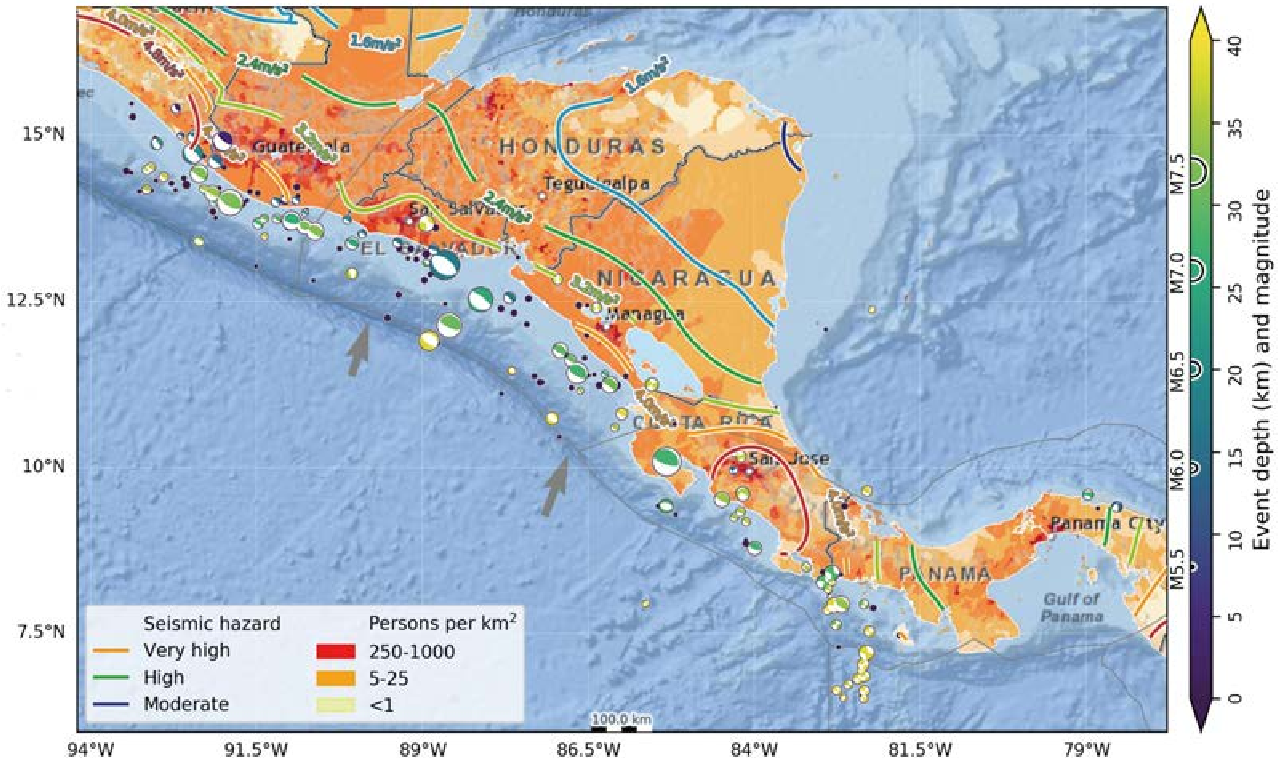

Figure 1: Map demonstrating seismic hazard in the region

Background

Nicaragua, Guatemala, El Salvador and Costa Rica are located along the edge of a large subduction zone that runs along the western coasts of all four countries. As a result, the region is prone to strong earthquakes and each has a history of devastating earthquakes occurring in living memory. The biggest earthquakes occur offshore and also present the most danger, however moderate events occurring under the main cities have also caused major destruction and loss of life.

The Project

Funded by the Swiss Agency for Development and Cooperation, Alerta Temprana de Terremotos en América Central (ATTAC), project included the national seismic networks in the region: Guatemala (INSIVUMEH), El Salvador (MARN), Nicaragua (INETER) and Costa Rica (OVSICORI-UNA); and the Swiss Seismological Service at ETH Zürich. The aim of the project was to build four independent Earthquake Early Warning (EEW) systems with modest resources capable of disseminating earthquake alerts to the public.

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Instrument requirements

In order to bolster the EEW capability of the existing seismic networks, the project called for strong motion broadband accelerometers with the capability to deliver low latency waveform data using SEEDlink. With this augmentation, national EEW systems could be built using the existing networks. Each agency operates the ETHZ-SED SeisComP EEW (ESE) software built and reliant on SeisComP. Additionally, it was important that the instrumentation had excellent noise resolution coupled with high performance and linearity during strong motion shaking to avoid the risk of the instrument clipping during major earthquakes.

Güralp solution

Güralp supplied 72 Fortimus units, which consist of a strong motion broadband accelerometer integrated with a Minimus digitizer in a single robust unit. The Fortimus is quick to install and offers advanced data communication capabilities as well as variable gain options for different earthquake shaking scenarios.

Güralp engineers worked closely with the team at ETH Zurich to optimize the sensors for use with their network design and low latency applications. Additionally Factory Acceptance Testing (FAT) test reports were supplied to ETH to ensure that all instrumentation was fit for use prior to deployment.

Figure 2: Fortimus Digital Accelerometer

Deployment

The Fortimus units were deployed during 2020-21, mostly in locations selected to minimise environmental noise and, as far as possible, away from urban areas. In many places, these were free-field vault sites. Each station has real-time data communication and a stable power supply. The low latency waveform data produced by the Fortimus is transmitted to SeisComP servers where two different EEW algorithms are run on the data to estimate event location and magnitude before alerts are issued.

The new Fortimus stations complement the existing network and enable rapid EEW alerts from a wide range of earthquake magnitudes. The improvement in network density is very different from country to country - ranging from Guatemala, where Fortimus constitute about 50% of the network, though in Costa Rica they are only 5%. Four years after initial deployment, the vast majority of sensors continue to operate flawlessly in the challenging tropical environment.


Figure 3: The Fortimus is installed in a thermally insulated vault


Figure 4: The vault is mounted on a concrete pillar, formed onto bedrock


Figure 5: A completed station

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Outcome

In 2024, at the time of project completion, public EEW alerts are now available in Costa Rica, Nicaragua and Guatemala. A public system is expected to be released imminently in El Salvador.

Public alerts are delivered through cell phone applications available on both iOS and android devices. In future, alerts may be delivered through sirens and digital TV. The systems will ultimately provide significant threat reduction to populations living in the region. Once EEW alert methodologies are established, it will be easier to enhance these to include tsunami and volcano alerts as well.

The system currently provides up to 10s of seconds of warning time in the event of a large earthquake to at-risk populations at some 10s of kilometers epicentral distance. Further research into the effects of increasing EEW station density will also have a positive impact on future and existing EEW system performance.

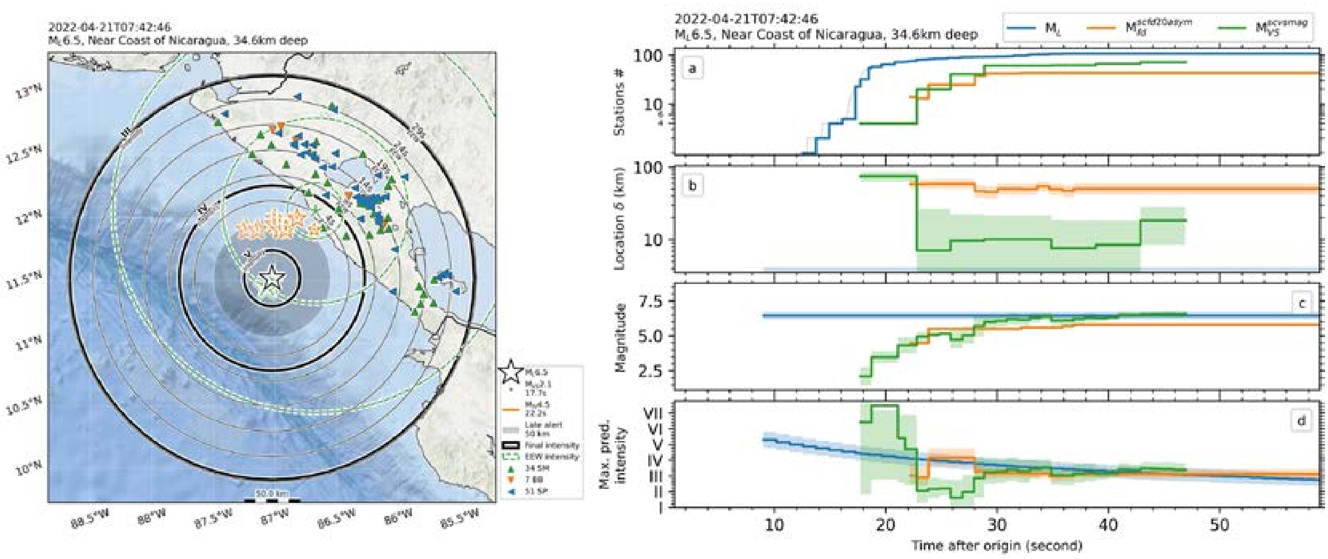

Figure 6: M6.7 Event detected 4 seconds before S-waves reached the coast

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