2022 Basin and Range Earthquake Summit (BRES)

Early Earthquake Warning (EEW) – Wednesday October 19

Session Conveners: Keith Roper (University of Utah Seismograph Stations) and Jayne Bormann (Nevada Seismological Laboratory)

Abstracts:

Benjamin Brooks	U.S. Geological Survey, Earthquake Science Center	Fixed Network Smartphone-Based Earthquake Early Warning
Sarah Doelger	UNAVCO Inc.	NOTA Realtime GNSS data for earthquake response in the Basin and Range
Graham Kent	University of Nevada, Reno	Future expansion of the EEW platform into Nevada using an Internet of Things (IOT) approach
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Natalia Ruppert	Alaska Earthquake Center, University of Alaska, Fairbanks	Towards Earthquake Early Warning in Alaska

FIXED NETWORK SMARTPHONE-BASED EARTHQUAKE EARLY WARNING

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ABSTRACT

We discuss an example of how off-the-shelf, low-cost sensor technology could be employed for earthquake early warning purposes. We show that a fixed smartphone network could provide robust Earthquake Early Warning for at least 2 orders of magnitude less cost than scientific-grade networks and could be stood-up in a matter of days. For Costa Rica, we evaluated a non-parametric ground-motion detection and alerting strategy with a threshold of 0.55-0.65 % at four neighboring stations. During a six-month evaluation period we detected and alerted on 5 of 13 earthquakes with M_w 4.8-5.3 that caused felt Modified Mercalli Intensity shaking levels of 4.3-6. The system did not produce any false alerts and the undetected events did not produce wide-spread or significant felt shaking. Alerts for all 5 detected events would have reached the capital city, San Jose, before strong S-wave shaking, affording time for Drop, Cover, and Hold On actions by most residents. An important result is that two of the five alerts were triggered by P-waves. This suggests that, with future improvement in sensors and/or algorithms, smartphone-based networks could approach the fastest theoretical EEW performance. We also show new results using the PLUM algorithm from a hybrid network of smartphones and the preexisting Costa Rican traditional seismic network. We show examples of how the increased density of smartphones permits faster alerts for the hybrid network in comparison to the traditional network alone. This suggests a simple and effective role for these low-cost sensors in future EEW build-outs.

NOTA REALTIME GNSS DATA FOR EARTHQUAKE RESPONSE IN THE BASIN AND RANGE

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ABSTRACT

Geodetic study of the Basin and Range has been supported by UNAVCO for over three decades. One of the first regional GPS networks to continuously measure extension rates of the Basin and Range was the BARGN (Basin and Range Geodetic Network) installed by UNAVCO in the late 1990's that later became part of a nucleus network for the Plate Boundary Observatory (PBO). Currently UNAVCO operates many of the original BARGN and PBO stations as part of the Network of the Americas (NOTA). NOTA is a core component of the NSF Geodetic Facility for the Advancement of Geoscience (GAGE), operated by UNAVCO. In recent years, UNAVCO has been upgrading the NOTA network in order to provide full GNSS (Global Navigation Satellite Systems) data availability and real-time 1Hz GNSS data products. Realtime stations in NOTA typically have data latency less than 1 second arriving at the data processing center. The extent of NOTA includes densely populated areas around Salt Lake City, Utah and Reno, NV. The NOTA station density in these populated areas provides geodetic data for future earthquake early warning efforts. In the event of a medium-large earthquake (~>M6.0), real-time position displacement data is utilized for rapid event magnitude estimation and measurement of coseismic displacement. UNAVCO also downloads high-rate 5-sps (5 Hz) data from all available NOTA GPS/GNSS stations within the area of anticipated coseismic surface displacement for post-processing. The use of real-time GNSS data allows for a geodetic-derived earthquake magnitude estimate within tens of seconds of the event. A case study from the M6.5 Monte Cristo Range earthquake on May 15, 2020 highlights the utility of real-time high-rate data for quickly derived earthquake magnitude even in areas of relatively low station density.

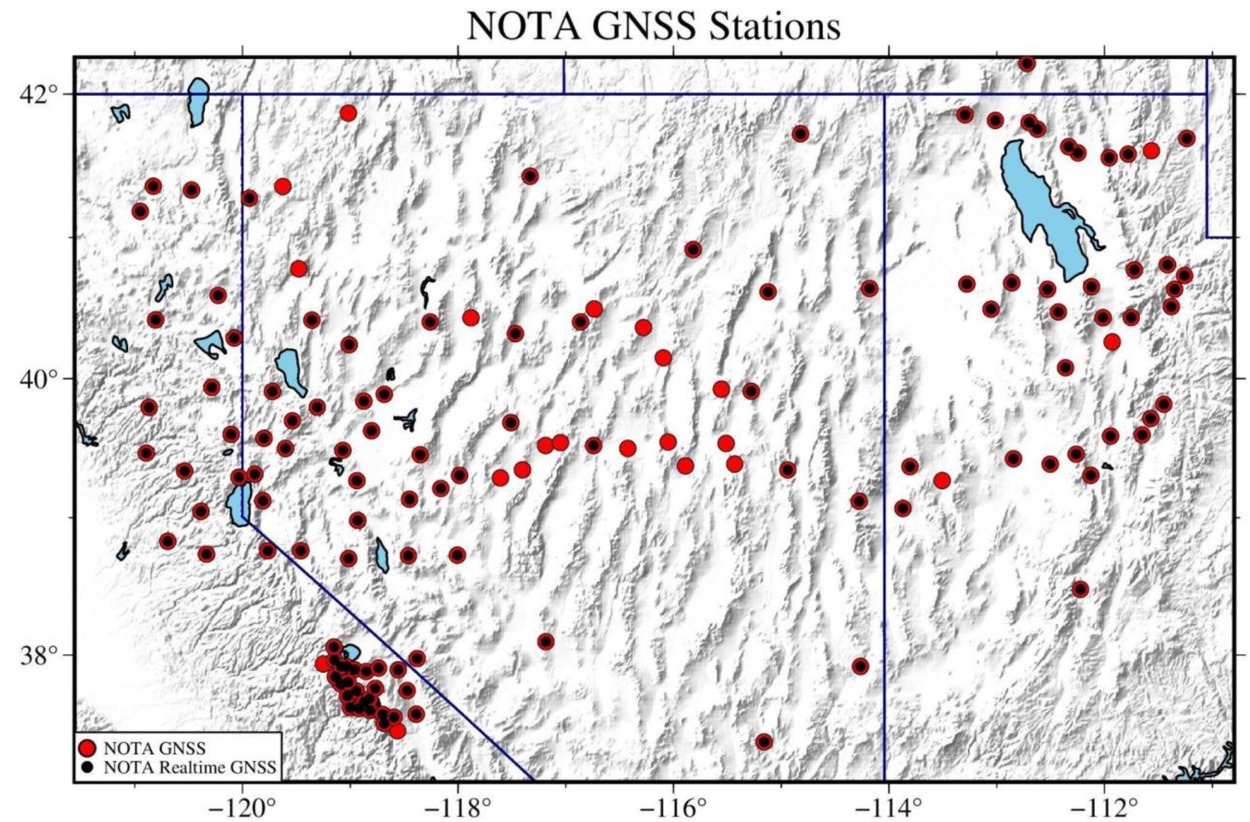

Figure 1. *NOTA GNSS stations located within the Basin and Range and vicinity.*

FUTURE EXPANSION OF THE EEW PLATFORM INTO NEVADA USING AN INTERNET OF THINGS (IOT) APPROACH

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ABSTRACT

With the potential for ShakeAlert to expand its geographic footprint eastward, transitioning to greater network resiliency and incorporation of low-cost sensors may provide the necessary combination to ensure reliable and timely warnings across the entire platform. This strategy may also provide an economically efficient framework for expanding earthquake early warning (EEW) deployments to less populated regions, where seismic hazard is nonetheless high. An Internet of Things (IOT) approach that leverages existing "points-of presence" (Figure 1) helps drive costs downward as several hazard applications (e.g., weather, fire & seismic) help support individual nodes and network backbone communications. The foundation of a reliable and resilient communication network for ShakeAlert is through a diversified set of data transmission paths to each instrumented site, such as a combination of point-to-point (PtP) microwave links, fiber drops and cellular backhaul. To achieve some reasonable service level agreement (SLA) target (e.g., 99.9 % uptime) upgrades to the current network topology are needed. The cost-performance of microwave links along with improvements in cellular reliability such as AT&T's FirstNet provide an opportunity to harden the ShakeAlert network without too much financial burden to the project. In remote locations, Starlink internet connectivity from a low-orbit constellation of satellites may be yet another opportunity to provide resiliency to outages resulting from weather events, wildfires, fiber-cuts and earthquakes. An expanded ShakeAlert system could leverage other microwave networks from existing commercial Wireless Internet Service Providers (WISPs), state-wide and county networks to provide alternative routes out for seismometers/accelerometers as demonstrated by the ALERTWildfire project in the western US. Together, these technologies can help build affordable mesh network topologies that can provide reliable failover through Open Shortest Path First (OSPF) routing strategies. Embracing the concepts of "points-of-presence," or more simply put, adopting the Internet of Things (IOT) approach, may be the best strategy for an expanded ShakeAlert system to achieve reasonable SLAs for data delivery, while bringing down costs for a truly resilient and hardened network. The Nevada Seismological Laboratory is piloting a low-cost sensor deployment across NSL's wireless IOT network in the greater Tahoe-Truckee ShakeAlert footprint to explore this approach. Some 20 low-cost sensors are going to be added to existing "points of presence" over the next 2 years to explore the cost-benefit of densifying the current eastern California EEW network in this manner, potentially further benefiting EEW in this seismically active border region.

Figure 1. *IOT EEW and ALERTWildfire site at Dollar Point, California.*

SOCIAL SCIENCE AND SHAKEALERT

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ABSTRACT

As of May 2021, rollout of public alerting of the ShakeAlert® Earthquake Early Warning (EEW) System, has been completed in Washington, Oregon, and California. Critical questions remain about what people understand and expect from ShakeAlert, including if they know what to do when they receive an alert. To evaluate whether the ShakeAlert System has been successful in answering these key research questions, the U.S. Geological Survey (USGS) collaborates with partners from the National Science Foundation, universities, emergency management and other state agencies, and USGS licensed alert distribution partners to implement a social science initiative focusing on three goals:

1. Understand earthquake risk perception, protective action knowledge, and basic earthquake preparedness across Washington, Oregon, and California populations.
2. The application of social science research to inform the ShakeAlert communication, education, outreach, and technical engagement (CEO&TE) programs.
3. Develop a monitoring and evaluation plan for CEO&TE programs for ShakeAlert.

The ShakeAlert social science initiative focuses on research that is currently underway and plans future directions to reach our goals. This extended abstract outlines the various publications that have been published or are in draft, future projects, and how social science research has been integrated into the ShakeAlert System.

TOWARDS EARTHQUAKE EARLY WARNING IN ALASKA

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ABSTRACT

Alaska is the most seismically active state in the United States. Seventy-five percent of all earthquakes in the United States with magnitudes larger than five happen in Alaska. Over the course of the past 5 years, there were 5 earthquakes with magnitudes over 7. All Alaskans live with earthquake hazards. Earthquake Early Warning (EEW) is a system for warning the public and automated alert systems that a significant earthquake has begun and that shaking will soon occur at their location. An EEW system for the Pacific Coast, known as USGS's ShakeAlert, is currently operational in California, Washington, and Oregon. Other systems have long been in place in Japan, Taiwan, parts of Mexico, China, and Korea. Developing such a system for Alaska faces many unique challenges: huge size of the region, wide range of earthquake sources, lack of communications and other robust infrastructure, and harsh climate. In 2022, the USGS Earthquake Hazards Program began working in partnership with the State of Alaska to fulfill the recent Congressional directive to deliver a written implementation plan describing what is needed to expand the USGS ShakeAlert System to Alaska. EEW in Alaska would need to be leveraged off of existing federal and state supported monitoring networks. The Alaska Earthquake Center is a participating regional seismic network for the USGS Advanced National Seismic System and is dedicated to strengthening Alaska's resilience to earthquakes and tsunamis through monitoring, research, and public engagement. Preliminary research conducted at the Earthquake Center indicates that warning times are possible for significant shaking intensities caused by the earthquakes along the subduction zone margin. These are the very 1st efforts towards advancing EEW possibility in Alaska.