

Real-Time Risk Reduction Through Early Warning, Earthquake and Volcano Monitoring in Southern California, USA

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More than 20 million people live in southern California, astride the Pacific and North America plate boundary. Caltech and USGS operate the Southern California Seismic Network (SCSN) to provide timely disaster mitigation in the form of early warning, event notification, ShakeMap, and other data products.

The earthquake early warning (EEW) project (ShakeAlert) analyzes SCSN data to identify the P-waves of earthquakes and issue warnings. The ShakeAlert prototype production system has been operating in a test mode for more than a year. Two point source algorithms report rapid earthquake magnitude and location that are received by UserDisplay and cell phone apps operated by pilot users. In the future, finite source algorithms will be added to the system to improve performance for the largest events.

Real-time processing provides accurate magnitudes and hypocenters within two minutes. Within 5 minutes, an accurate ShakeMap of the peak amplitudes of shaking provides a geographical view of potential damaging shaking for emergency responders. In the same time frame, a seismic moment tensor to identify the causative fault and evaluate tsunami hazards is available. In the case of unusual activity, seismologists provide near real-time situational awareness to warn civic authorities of increased hazards levels. We also operate seismic swarm detectors to identify possible onset of volcanic activity, alerting civic authorities.

The SCSN processes data real-time and routinely archives more than 15,000 earthquakes every year; in case of a large sequence, it may archive more than 60,000 events per year. The Southern California Earthquake Data Center (SCEDC) archives the data and facilitates the use of the SCSN data for scientific research, earthquake engineering, and public communication. All 80TB of data produced by the SCSN are freely distributed via the SCEDC; waveform data are made available online within minutes of the occurrence of an earthquake. The magnitude completeness level since 1981 is M1.8, on average, within the SCSN reporting region. The template-matching catalog that is being constructed for the SCSN will have a completeness level of approximately M0.0, as template matching detects 20 to 30 times more events than the regular catalog.

The performance goals of the SCSN are to deliver data for earthquake early warning (EEW) processing within 0.5 sec as well as a continuous stream of data for archiving and future processing. The SCSN records real-time seismic data from more than 500 stations. To capture data on scale, these stations have 24-bit digitizers with a variety of sensors, including strong motion, broadband, and short-period sensors. By using two sensors at each station, the SCSN has the capability of recording data on scale for a magnitude range from < M0 to > M8. To ensure timely data delivery and redundancy in data communications the SCSN uses cell modems, microwave, radio, and satellite links for data communications. We use various tools to monitor the state of health of stations, primarily to detect data latency, and sudden changes in data quality. To ensure data integrity the SCSN uses virtual private networking (VPN) to secure data delivery from remote stations. For data processing we use AQMS and earthworm software, and parametric data are stored in an Oracle database. Metadata are maintained in

the Station Information System Database (SIS), which is a relational database designed to store equipment inventory and produce metadata information in a variety of formats, including dataless SEED and station XML metadata information.

To take advantage of publicly available cloud computing facilities, we have already migrated some of our operations into the Amazon web services cloud (AWS). We plan to distribute products from the AWS and maintain a long-term archive in the AWS Glacier facility. This will significantly reduce the vulnerability of SCSN and SCEDC operations during future earthquakes in southern California.

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