The California Integrated Seismic Network: Status and Perspectives

The CISN Program Management Group:
Lind Gee, Doug Given, Egill Hauksson, David Oppenheimer, and Tony Shakal

Abstract

The California Integrated Seismic Network (CISN) is a collaboration among federal, state, and academic institutions engaged in earthquake monitoring in California and represents California as a designated region of the Advanced National Seismic System (ANSS). The CISN is governed by a Steering Committee representing institutions actively involved in earthquake monitoring in California. The institutions that currently comprise the CISN are the United States Geological Survey (USGS), California Geological Survey (CGS), UC Berkeley (UCB) and the California Institute of Technology (Caltech) and the California Office of Emergency Services (OES).

A major goal of the CISN is to ensure a more uniform system for earthquake monitoring, through the improvement of seismic infrastructure in northern California and continued maintenance of the TriNet system in southern California. Another major goal is to integrate the earthquake monitoring and reporting efforts in California, utilizing compatible software and creating a single catalog. In particular, the CISN is working to improve the robustness of statewide rapid notification and work with the California OES and other emergency responders to maximize the use and benefit of this real-time seismic information.

In the past year, with support from the State of California through the Office of Emergency Services and from the ANSS program of the USGS, more than 50 new strong-motion stations were installed, with a focus in the San Francisco Bay Area, in order to improve coverage for ShakeMap (Wald et al., 1999). The CISN is calibrating and standardizing earthquake processing systems statewide and has installed a private network to provide a dedicated communications infrastructure among the participating centers. The CISN is developing an application to provide emergency managers and other users with real-time seismicity and other hazards information, such as a ShakeMap, automatically. The CISN has also implemented the CISN Engineering Data Center to rapidly distribute statewide strong motion data for effective post-earthquake engineering use for damage assessment, and to support analysis of such data for reducing losses in future large earthquakes through improvements in building code and land use.

Introduction

It may seem surprising that California did not have an integrated seismic network (Figure 1). In fact, the history of earthquake monitoring in the state - and across the nation - is one of numerous, independent operations, each with its own special mission and focus. In California, we have had both geographical division (between north and south) and instrumentation division (between recording both small earthquakes to define seismicity and tectonics and large earthquakes that produce damaging shaking) (Figure 2).

This patchwork of networks has complicated real-time emergency response as well as long-term studies for mitigation, as each agency has had only a partial or incomplete view of an earthquake. It is the goal of the CISN to combine these networks so that a seamless picture of the earthquake is available in real-time as well as in the long-term.

Advances in technology have made it possible to integrate separate earthquake monitoring networks into a single seismic system as well as to unify earthquake monitoring instrumentation. In California, this effort was initiated under the TriNet Project in southern California in 1997, when Caltech, the California Geological Survey (formerly the California Division of Mines and Geology), and the USGS combined efforts to create a unified seismic system for southern California. With major funding provided by FEMA, OES, and the USGS, the TriNet project provided the opportunity to upgrade and expand the monitoring infrastructure, combining resources in a federal, state, university partnership. As a result, new products have been developed for emergency response, such as ShakeMaps (maps of ground motion and shaking intensity) and strong motion data collected for earthquake engineering and design.

In the fall of 2000, representatives from the USGS, CGS, UC Berkeley (UCB), Caltech, and the California Office of Emergency Services signed a Memorandum of Agreement that describes the CISN organizational goals, products, management, and responsibilities of member organizations. A Steering Committee oversees CISN projects, and an external Advisory Committee, representing the interests of structural engineers, seismologists, emergency managers, industry, government, and utilities, provides review. Other CISN committees include the Program Management Group (for planning, coordination, and implementation), the Strong Motion Working Group (for focus on issues related to strong-motion data), and the Standards Committee (to resolve technical design and implementation issues).

Organization

There are four major components to the CISN effort:

- Increasing robustness
- Standardizing products
- Improving the distribution of seismic instrumentation
- Dissemination of earthquake information

In order to accomplish these goals, the CISN is organized into three management centers - the Northern and Southern California Earthquake Processing Centers and the Engineering Data Center.

The two California processing centers are dedicated to routine, automated earthquake monitoring. UC Berkeley and the USGS Menlo Park form the Northern California Management Center, while Caltech and the USGS Pasadena form the Southern California Center. These centers have the responsibility for the rapid and reliable determination of earthquake location, magnitude, and shaking distribution for any significant event in the state.

The Engineering Data Center is the element of the CISN that provides seismological data products to improve building codes, structural design, and construction practices so that structures can withstand earthquake shaking with little or no damage. The California Geological Survey and the USGS National Strong Motion Program operate the Engineering Data Center.

Progress

The development of the CISN is a multi-year effort. In the first years we are focusing primarily on issues related to statewide robustness, such as improved communication links among the participating networks, calibration of software to ensure product standardization, and exchange of data to establish statewide processing capabilities. We are also beginning to work on improved tools for the display of earthquake information for emergency response.

Increasing Robustness

The CISN has taken two major steps to improve the robustness of earthquake monitoring in California. The first is to establish a dedicated communications ring connecting the CISN partners (Figure 3). The CISN backbone was brought online in the fall of 2002. It consists of ring of dedicated T1 connections, with Internet "tunneling" to allow communications to continue if one or more dedicated links fail. The CISN partners are using the communications ring to exchange data such as waveforms and parameters as well as information products. The second significant step to improve robustness is the establishment of seismic stations with feeds to multiple centers. As part of the TriNet project, Caltech and the California Geological Survey established dual data feeds to 5 strong-motion stations in the Los Angeles area. This year, the CISN added 20 sites with combined broadband and strong-motion instrumentation (Figure 4). These sites send data simultaneously to Caltech and to UC Berkeley. The CISN hopes to expand the dual feed process to 60 stations by 2005.

Standardizing Products

A goal of the CISN is to operate dual statewide processing centers at the Northern and Southern California Management Centers. That is, each center should have the capability to detect, locate, and determine the parameters for all earthquakes statewide (Figures 5 & 6). In addition to sharing seismic data, the CISN partners have needed to calibrate and standardize their processing software, as different software systems have been developed in northern and southern California.

The Program Management Group and the Standards Committee have worked together in the last year to initiate this process. A working group has been addressing issues of waveform pickers, pick filters, association algorithms, and location programs. Most of this core software is common among the CISN partners, although configuration differences are significant, particularly for the association algorithm. Another working group has been looking at the issues associated with magnitudes – duration, local, energy, and moment. A third working group has been addressing the problem of exchanging amplitude information for producing ShakeMaps and other products. In addition to these specific issues, the CISN is examining how to exchange seismic station and related metadata, which is essential to proper use of seismic data.

This is a significant effort and is well underway. Future issues to be addressed include the development of software to assess and monitor "state-of-health" (critical in a distributed system such as the CISN), the unification of information distribution system, and the establishment of protocols for rapid earthquake reporting.

Improving the distribution of seismic instrumentation

As part of the TriNet project, the instrumentation in southern California was significantly upgraded and expanded from 1996-2001. Today, over 150 sites have co-located broadband and strong motion sensors and over 400 sites have strong-motion sensors with modern digital recording and communication. In northern California, progress in upgrading instrumentation has been somewhat slower, and a significant fraction of the stations are still analog. Today, over 30 sites have collocated broadband and strong motion sensors and approximately 150 sites have modern strong motion sensors. The urban cores of the San Francisco Bay Area and the Los Angeles Basin have comparable levels of instrumentation, largely focused on the recovery of ground motions for use in products such as ShakeMap and engineering applications.

Distribution of earthquake information

The CISN web site www.cisn.org (Figure 7) serves as a portal to CISN activities and accomplishments as well as links to earthquake information. The Web site received a great deal of attention after the Nov. 2002 and Feb. 2003 earthquake swarms in the San Francisco Bay Area. The CISN issued "special reports" for each sequence and posted them at www.cisn.org. The reports contain information about the events, the observed ground motions, and background on the seismicity.

In parallel, the CISN Engineering Data Center has developed a new product for the Web – the Internet Quick Report or IQR (Figure 8). The IQR complements the regional view of shaking provided by ShakeMap though detailed information on the shaking at specific sites. The IQR is available at docinet3.consrv.ca.gov/csmip/cisn-edc/iqr1.htm.

In addition to these developments, the CISN is developing an integrated Web-enabled notification system, called *CISN display*. The Java-based desktop application provides users with a display of real-time seismicity, alerting capability, GIS-mapping, and links to additional products such as ShakeMap. This product is currently being beta-tested and is designed to replace the *CUBE/REDI display* system developed in the early 1990s.

Future Developments

The CISN partners have made significant progress in the past two years. However, considerable work remains to achieve the goals of seamless and robust statewide earthquake reporting.

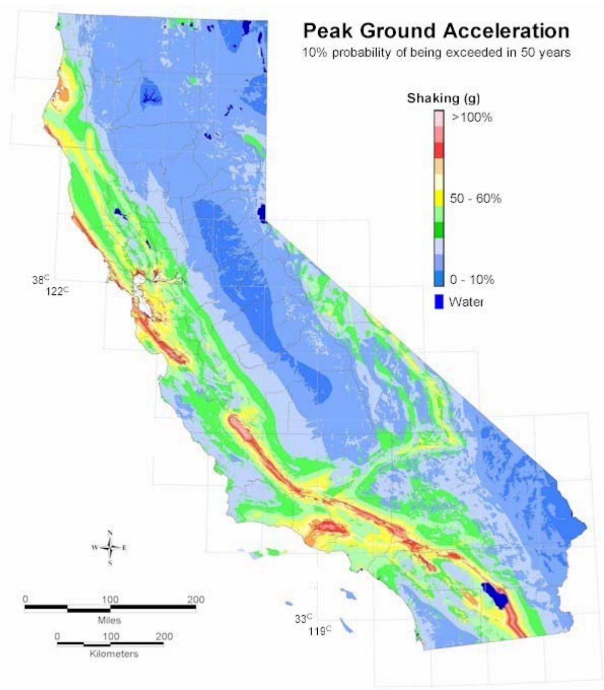
Additional information on the CISN is available at www.cisn.org, including quarterly progress reports and reports from the Advisory Committee.

Dr. Lind S. Gee
Berkeley Seismological Laboratory
215 McCone Hall
UC Berkeley
Berkeley CA 94720-4760

510-643-9449 phone
510-643-5811 fax

lind@seismo.berkeley.edu

www.cisn.org



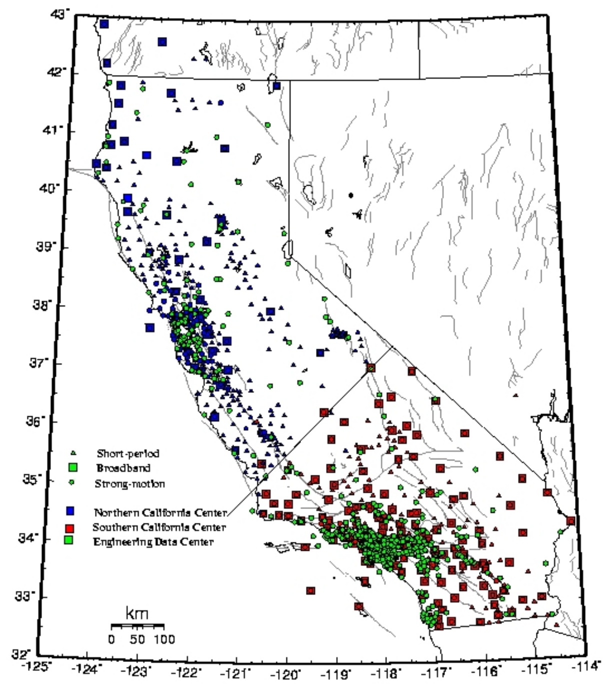
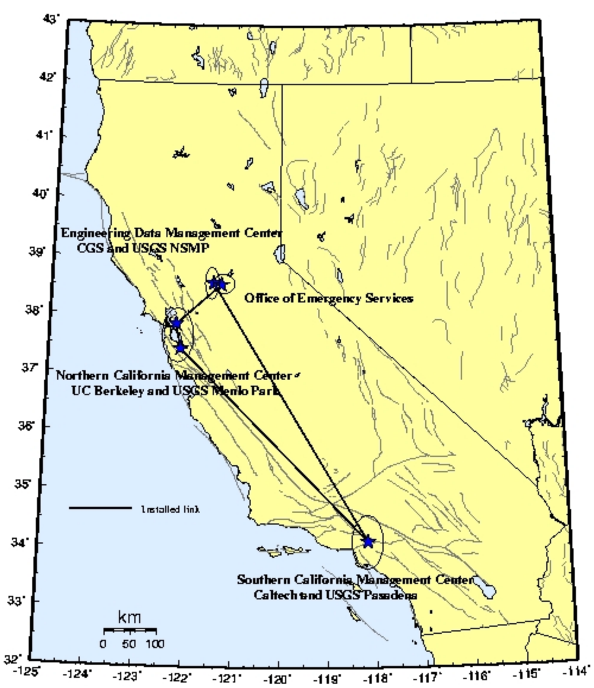


Figure 1: Map illustrating that earthquakes are a statewide problem in California – and that the earthquake processing centers in Berkeley, Menlo Park, and Pasadena are vulnerable to strong shaking.

Figure 2: Map showing the distribution of seismic stations in California



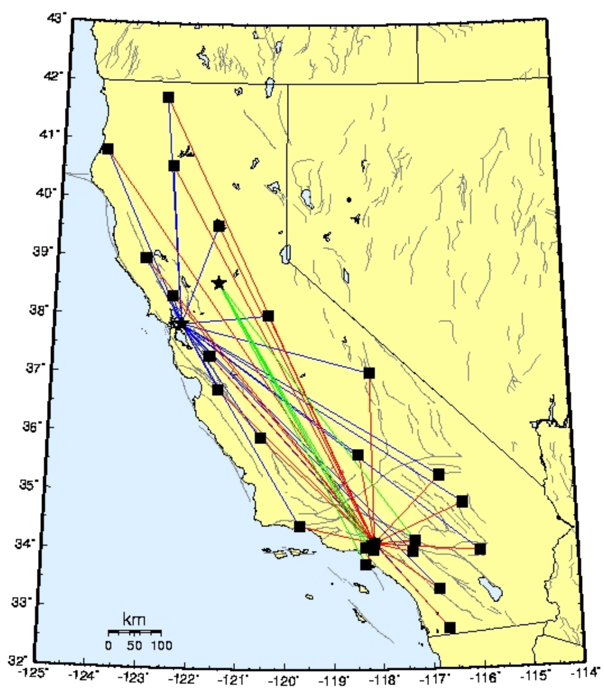


Figure 3: Map showing the dedicated T1 communications ring connecting the CISN centers. The ring is designed to fall back to the Internet if a connection fails. The ring is used to exchange data as well as information products.

Figure 4: Map showing the 20 stations sending data to both the Northern and Southern California Management Centers (blue and red) and the 5 stations sending data to both the Engineering Data and Southern California Management Centers (green).

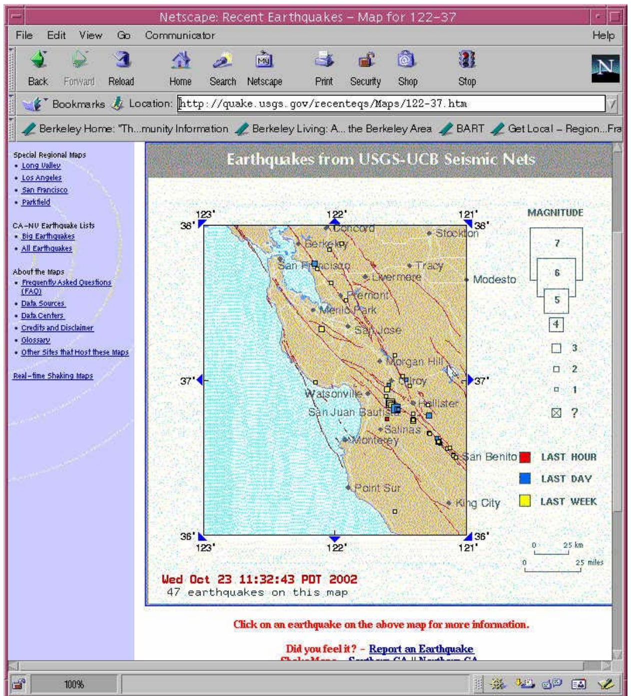


Figure 5: Example of a "recenteqs" Web page for an event in the San Francisco Bay Area. These pages are produced automatically and include details on event location.

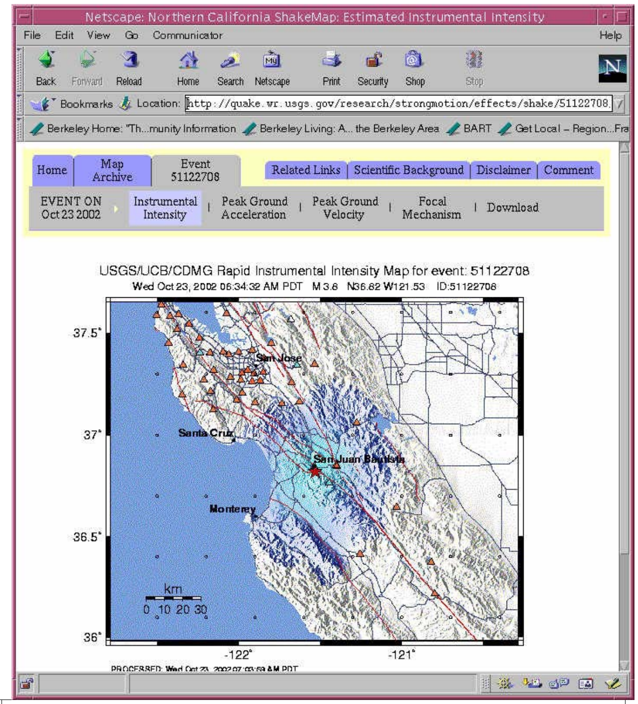


Figure 6: Example of a ShakeMap showing the distribution of intensity for event in the San Francisco Bay Area. This product provide useful information for emergency response.

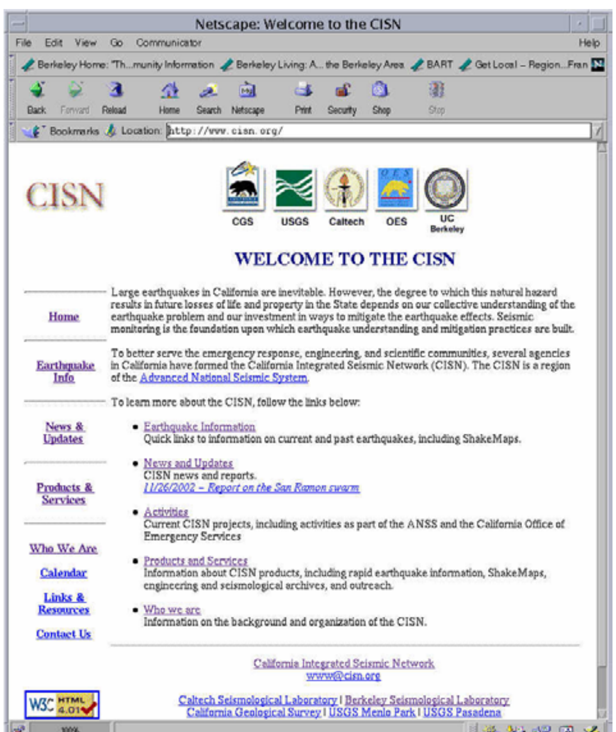


Figure 7: Snapshot of the www.cisn.org Web site.

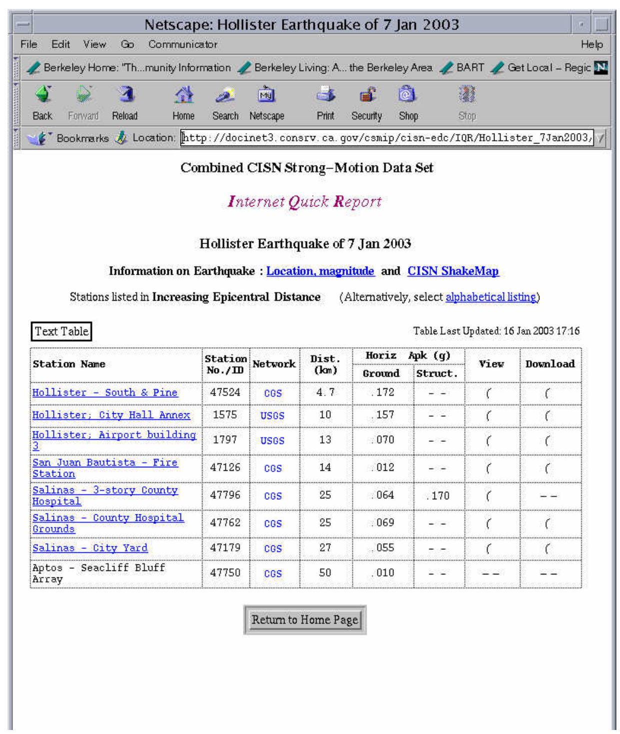


Figure 8: Snapshot of the Internet Quick Report for the January 2003 Hollister earthquake.