Partial Support of Joint USGS-CALTECH Southern California Seismographic Network

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INVESTIGATIONS

This Cooperative Agreement provides partial support for the joint USGS-Caltech Southern California Seismic Network (SCSN). The purpose is to record and analyze data from more than 11,736 local earthquakes from October 2002 to September 2003 and generate a database of phase data and digital seismograms (Figure 1). The primary product derived from the database is a joint USGS-Caltech catalog of earthquakes in the southern California region and the associated waveforms. We maintain the SCSN infrastructure. We also provide rapid response to emergency services, the media, and public inquiries about earthquakes.

For more detailed information about data access, please contact:
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RESULTS

Network Operation

The SCSN operation of network infrastructure consists of: 1) operating computer and communications hardware/software and other instrumentation for data acquisition at the central site; 2) installation and field maintenance of new and existing digital stations; and 3) population and maintenance of earthquake databases. Caltech and USGS personnel

share these operations responsibilities. Because the SCSN is a cooperative project of Caltech and USGS, all the facilities listed below are jointly operated and contribute to the overall project mission.

Central Site. The SCSN (formerly TriNet and TERRAscope) differs from most regional networks in both size and data processing approach. Most of the data are transmitted using digital communications, products are generated in near-real-time, and automatically archived in an Oracle database.

We lease frame relay from SBC and Verizon for data communications. This includes more than 120 frame relay drops, over 30 "last mile" radio links, 20 "last mile" optical fiber links, and three T1 lines transmitting the data from the frame relay cloud into the Caltech campus. Through agreements with the local utilities, we operate three T1 microwave links that provide wireless data transmission for about 40 stations using their statewide microwave systems.

The data from approximately half of the analog short period stations are digitized at four different remote earthworm hubs. The remaining stations are transmitted via analog phone lines and the USGS microwave to Caltech and digitized at the central site. In 2003, the USGS plans to decommission the microwave system and deploy a fifth earthworm hub at Edwards Air Force Base, using a leased T1 line to bring the data back to Pasadena.

Two SUN servers, with 8 CPUs each, operating in primary and backup mode, perform the real-time data acquisition and processing. To improve robustness, these two servers and related equipment are located in two different buildings on campus, the Seismo Lab and the USGS building (525 So. Wilson Ave). Two SUN servers are used for software testing and development. ShakeMap is generated using a SUN server and will also be produced in the future using a 2 CPU LINUX server.

Both parametric and waveform data are archived automatically in the oracle database. The data analysts review and modify the already archived data in the Oracle database. A significant part of our effort is also the maintenance of existing data archives and station metadata for the stations recorded by SCSN.

The major software components used by SCSN are TriNet C++, Perl scripts, and Java software, earthworm modules, and commercial software such as Oracle, SmartSockets, and Roguewave. This software requires extensive maintenance because software and hardware need to be upgraded simultaneously, requirements such as station metadata may change and send ripples through the software. Further, improvements in seismological algorithms may need to be incorporated as errors or improvements are discovered.

SCSN. The SCSN operates 155 broadband and strong motion real-time digital stations, 30 real-time strong motion stations, and about~120 short period stations to maintain the detection threshold of M1.8 in southern California (Figure 2). The existing digital stations of TERRAscope are part of SCSN.

Broadband and strong motion sites, provide flat instrument response from 50 Hz-30 seconds or greater. Approximately two thirds of the broad sensors have low frequency response to 120 or 360 seconds. They are sited, away from structures of two or more stories, and preferentially at sites with low ambient ground noise. At present we

operate 155 broadband and strong motion stations and record data from 10 Anza network stations, 3 University of California borehole stations located on the major campuses, and 4 SCEC borehole strong motion stations.

Strong motion reference sites, differ from traditional free field sites. The reference sites must provide flat instrument response in acceleration and on scale recording up to 2 g. In some cases these sites will also have a broadband seismometer. They will be sited away from structures of 2 or more stories but are located near major facilities or near groups of significant structures. Nearly all of the SCSN stations are either reference sites or free field sties. All strong motion sites have local recording. At present we receive signals from 15 Caltech operated K2's.

Short period sites*,* that have a single vertical component seismometer, are needed to ensure the minimum magnitude threshold of M1.8. These are quiet sites that provide resolution down to ambient ground noise.

State of health*,* we monitor the state of health of the network using SeisNetwatch. SeisNetwatch can be operated remotely using a regular web browser and field engineers can be notified via paging or email in case problems develop. SeisNetwatch is a good example of how the seismic network community has benefited from TriNet development. Initially, it was developed as TriNetwatch and was made available to the community as SeisNetwatch at the request of the USGS earthworm group in Golden Colorado.

Data transmission. The SCSN data are transmitted to Caltech via frame relay, digital microwave, Internet, and spread spectrum radio. We lease three T1 frame relay lines from Pacific Bell, which terminate at Caltech. At six locations, we collect several stations before the data are put onto frame relay lines, with three stations sharing a single frame relay line. Connecting to remote sites, we lease more than 120 frame relay circuits. For communications we operate, two 3 T1 capacity CISCO routers, a Motorola router, and several terminal servers. We also operate a 2 T1 capacity digital microwave link to Mt. Lukens to connect to the So Cal Edison and City of Los Angeles Department of Water and Power wide area networks. Further, we operate a third last mile microwave link to Verdugo Peak for data transmission from sites located at Southern California Gas Co. sites.

The Southern California Earthquake Data Center. This center has significantly increased the use of the data from SCSN/CISN for scientific research. The web enabled system, which has been in operation for more than ten years, provides on-line storage for more than 5000 Gbytes of data. These data, including, 70 years of catalog, 70 years of phase data, and 20 years of digital seismograms are available through the internet in near real-time.

Seismicity Summary for Southern California

October 2002 - September 2003

In and just outside of the Southern California reporting region, there were:

11,736	earthquakes & quarry blasts, of which
1,736	were magnitude 2.0 or larger,
156	were magnitude 3.0 or larger &
20	was magnitude 4.0 or larger.

The year's largest quake, and the most widely noticed by the public, was the ML5.4 on February 22, not far from Big Bear City in the San Bernardino Mountains (Figure 1). The Community Internet Intensity Map (CIIM) got 7,532 reports from 570 zip codes, some as far away as Nevada and Arizona. The peak intensity, in the epicentral area, was Modified Mercalli VI. There were several hundred aftershocks, including the seven M4.0+ events listed above.

Also of interest were the two M4.0+ Hector Mines aftershocks: the ML4.8 on October 29, southwest of Baker, and the ML4.6 on March 11, north-northwest of Twentynine Palms. Both of these quakes were reported felt by many people in the High Desert regions and the Inland Empire.

There was also a ML4.5 quake in the Tehachapi Mountains, northeast of Arvin and south of Lake Isabella, on January 25. This quake attracted 380 CIIM reports from 56 zip codes, with a peak intensity of Modified Mercalli V (in Caliente).

The 4.0 and larger earthquakes are listed below:

Mag.	Date	Time	Latitude	Longitude	Depth	Desciptive location
4.8	10/29	06:16:54	34 48.2 N	116 16.0 W	4.6	34 mi SSW of Baker
4.2	11/12	08:48:25	35 57.7 N	120 34.1 W	9.4	9 mi WNW of Parkfield
4.1	11/26	05:45:51	32 6.0 N	115 0.4 W	7.0	47 mi SSW of Yuma AZ
4.8	12/10	13:04:00	32 13.9 N	115 47.9 W	7.0	35 mi SSW of Calexico
4.0	12/10	13:47:15	32 13.5 N	115 47.7 W	7.0	35 mi SSW of Calexico
4.2	12/12	13:03:43	32 22.0 N	115 12.1 W	7.0	27 mi SE of Calexico
4.5	01/25	01:16:10	35 19.1 N	118 39.2 W	5.6	12 mi NE of Arvin
5.0	02/07	02:34:04	31 37.7 N	115 30.6 W	7.6	72 mi S of Calexico
5.4	02/22	04:19:10	34 18.6 N	116 50.9 W	1.2	3 mi N of Big Bear City
4.0	02/22	04:20:15	34 18.7 N	116 50.8 W	4.4	3 mi N of Big Bear City
4.3	02/22	04:21:33	34 18.6 N	116 51.0 W	4.4	3 mi N of Big Bear City
4.0	02/22	04:25:13	34 19.6 N	116 51.4 W	9.3	4 mi N of Big Bear City
4.1	02/22	06:16:08	34 19.5 N	116 51.5 W	4.2	4 mi N of Big Bear City
4.5	02/22	11:33:45	34 18.6 N	116 51.0 W	3.0	3 mi N of Big Bear City
4.6	02/24	20:03:04	34 18.9 N	116 50.7 W	2.7	4 mi N of Big Bear City
4.0	02/26	21:00:21	34 18.3 N	116 50.6 W	4.6	3 mi N of Big Bear City
4.6	03/11	11:28:17	34 21.6 N	116 8.0 W	3.9	16 mi NNW Twentynine Palms
4.2	05/23	19:04:28	32 56.9 N	115 33.0 W	16.0	1 mi SW of Brawley
4.1	06/25	23:20:01	32 0.9 N	117 23.0 W	6.0	42 mi SSW of San Ysidro
4.2	07/14	23:15:50	34 37.3 N	116 40.0 W	7.6	20 mi NE Lucerne Valley

Processing of Backlog of SCSN Data

We have made more progress in processing earlier backlogs. Events from 1932 through 1976 now have computerized locations and magnitudes consistent with our current calibrations. All data from 1932 onward has been written to the Oracle data base,

although some time periods in 1983 and 1981 have not been completely processed. All of the CEDAR system data (1977 through 1980) that are readable from the tapes of that period have been translated from CEDAR format to CUSP & are being converted into the Oracle data base.

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Southern California

Seismicity October 2002 -- September 2003

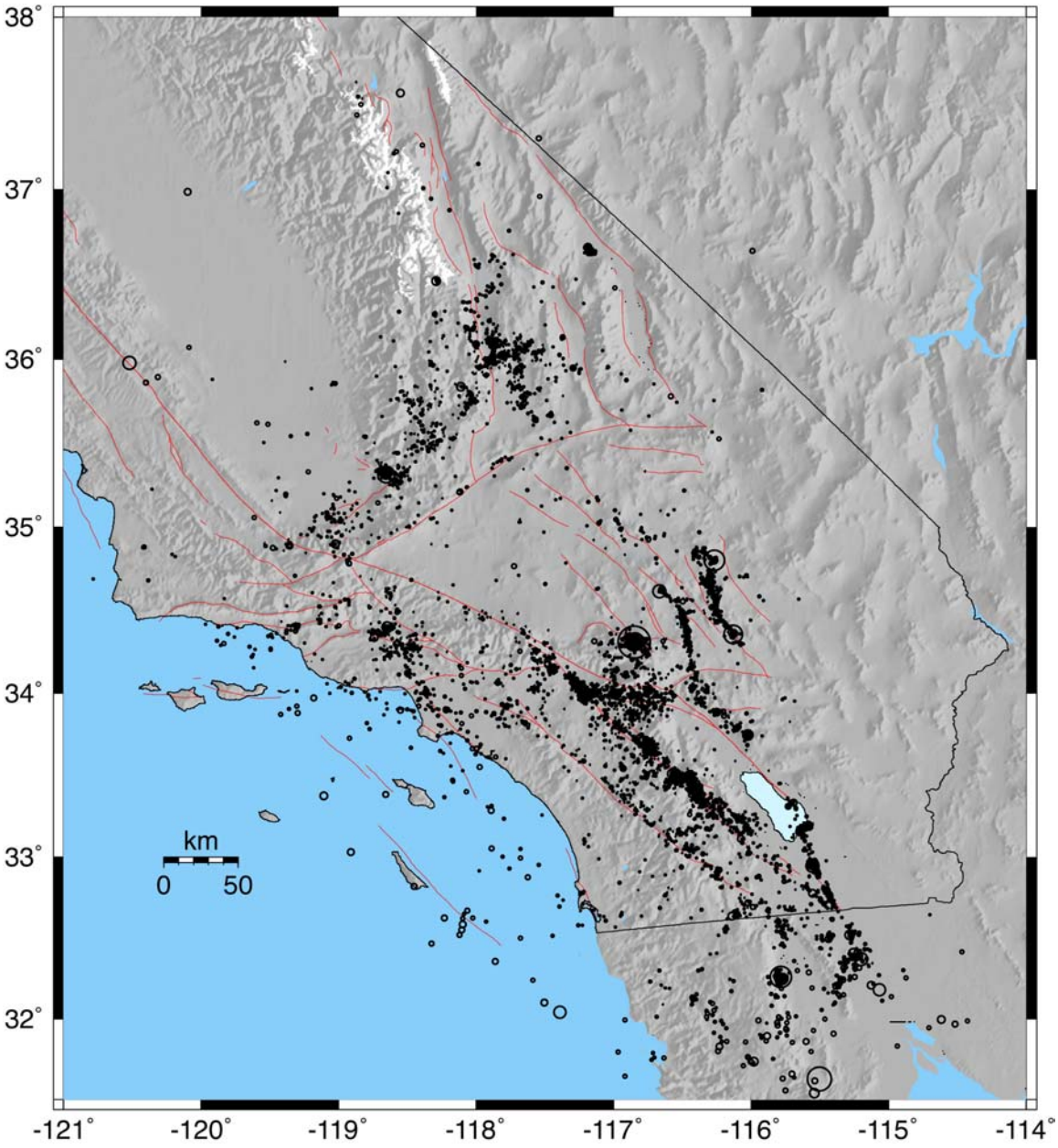

Figure 1. Earthquakes recorded by SCSN/CISN., http://www.trinet.org

Caltech-USGS TriNet

Current Configuration 2003

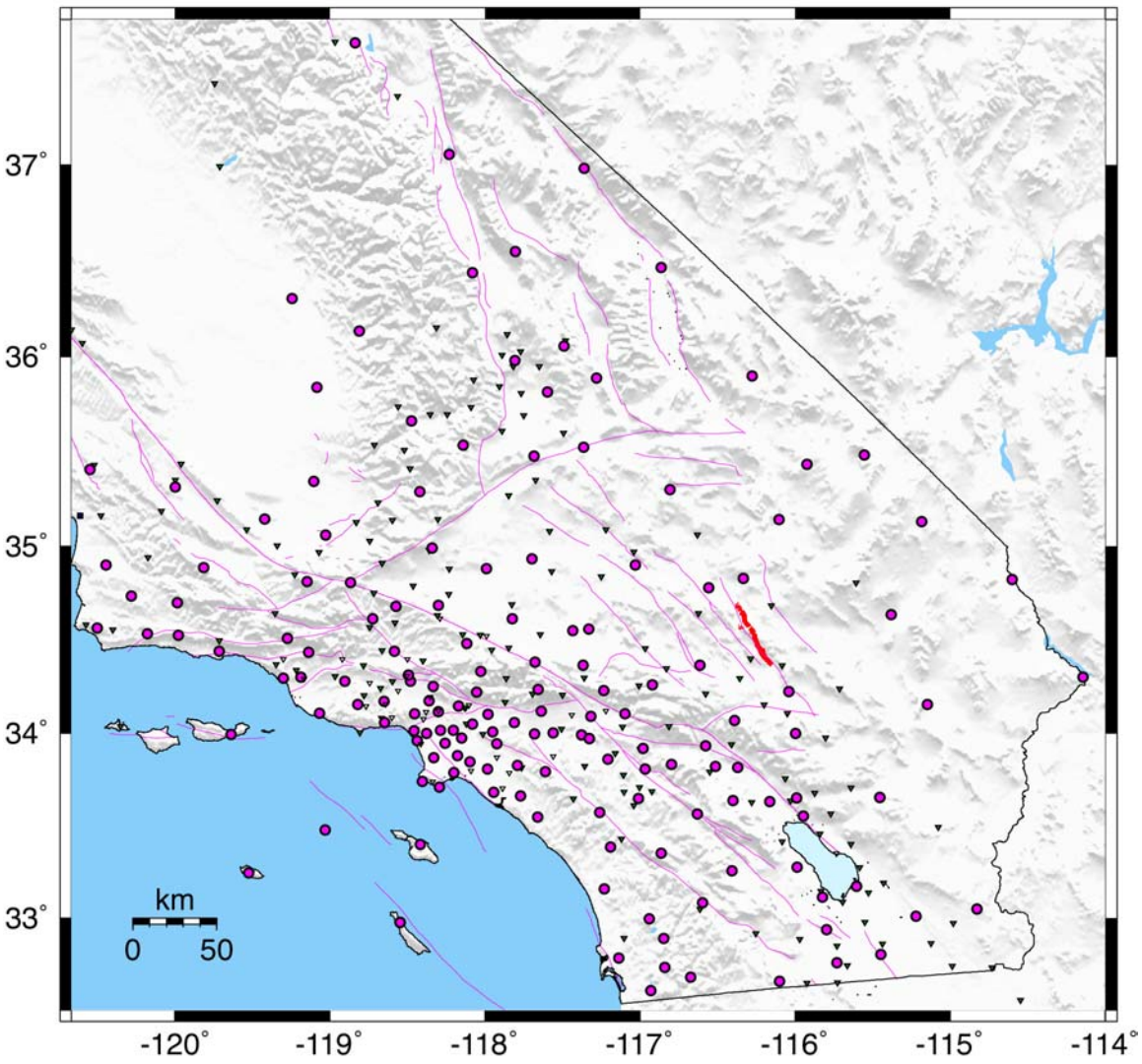

Fig. 2. TriNet digital broadband and strong motion (circles) seismic stations, strong motion (triangles), planned (squares), short period stations (inverted triangles).

Partial Support of Joint USGS-CALTECH Southern California Seismographic Network

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This Cooperative Agreement provides partial support for the joint USGS-Caltech monitoring of earthquakes in southern California. We recorded and analyzed data from more than 11,736 local earthquakes in FY2003. We also maintain field equipment located at remote sites and equipment and software at the central site in Pasadena. The primary product is a database of earthquake data, which includes a joint USGS-Caltech catalog of earthquakes in the southern California region. We also provide rapid response to emergency services, the media and public inquiries about earthquakes. For information about data access, please contact: Dr. Kate Hutton at (626) 395-6959.

NON-TECHNICAL SUMMARY