The California Integrated Seismic Network

(CISN)

Author Information:

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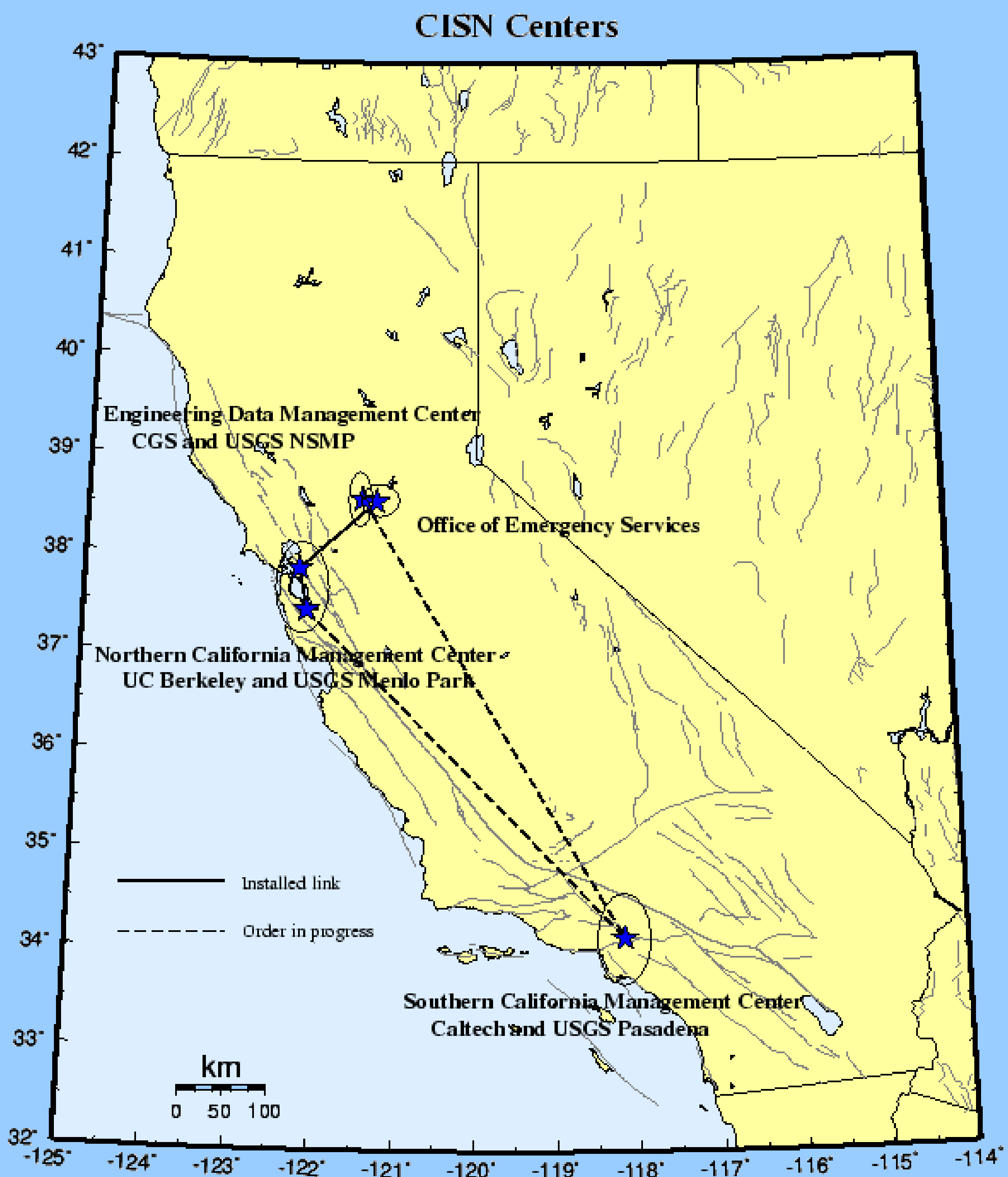
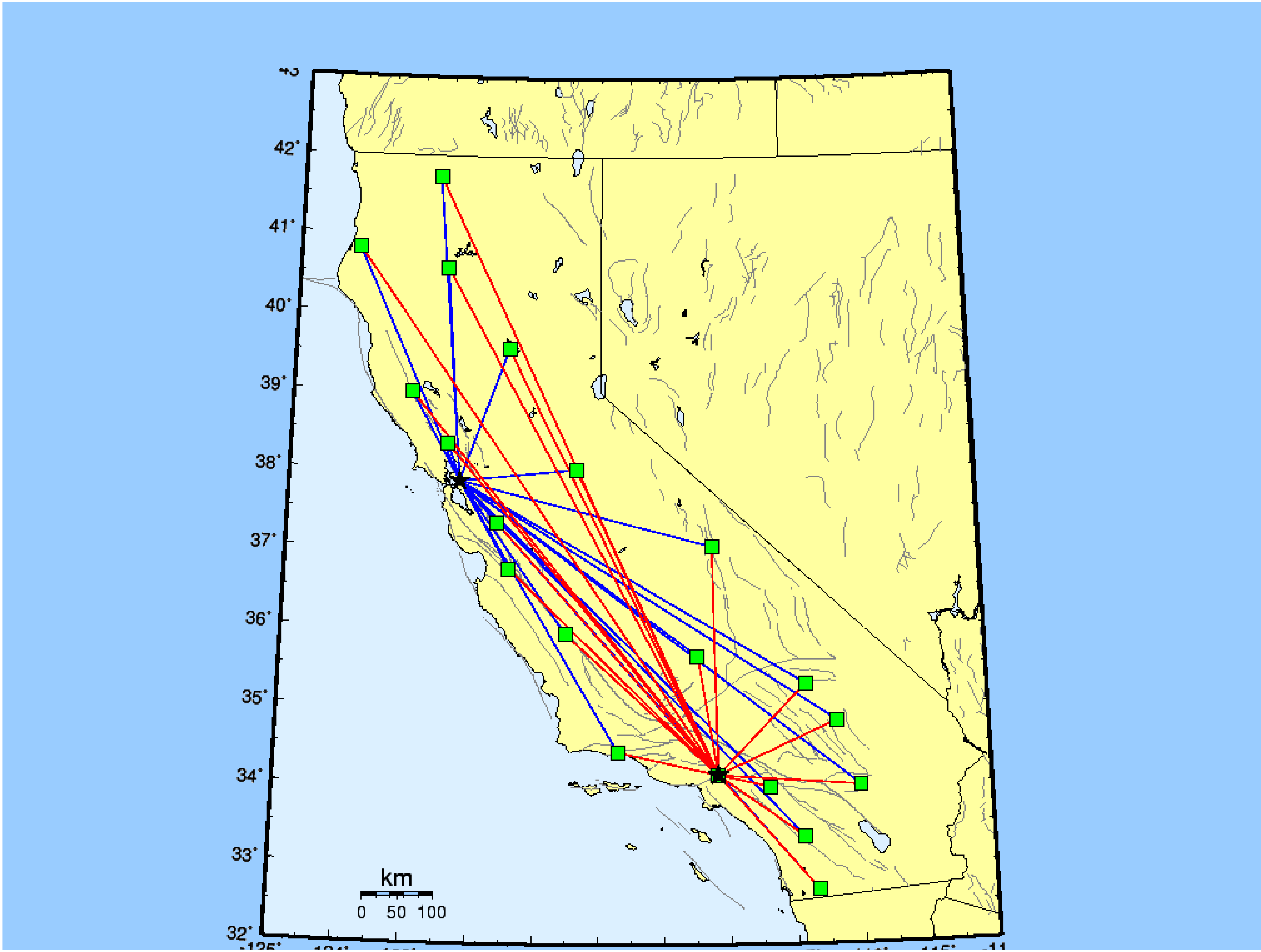
Abstract:

The California Integrated Seismic Network (CISN) is a partnership among federal, state, and university agencies involved in California earthquake monitoring. The CISN is dedicated to serve the emergency response, engineering, and scientific communities. The CISN is a region of the Advanced National Seismic System (CISN Introduction). The Department of Water Resource (DWR), Dam Safety Division, Earthquake Engineering section is also an intricate part of the CISN by attributing seismic data through the Earthworm network data acquisition and processing system which allows all the integrated seismic systems to communicate with each other.



"Map showing the geographical distribution of the CISN partners and centers. The communications "ring" is shown schematically with installed links (solid lines) and ordered links (dotted lines)". (CISN 2007-2008 Activities)


42˚
41˚
40˚
39˚
38˚
37˚
36˚
35˚
34˚
33˚
32˚
km
0 50 100

"Map showing the 20 stations selected to send data directly to the northern and southern California processing centers". (CISN 2007-2008 Activities)

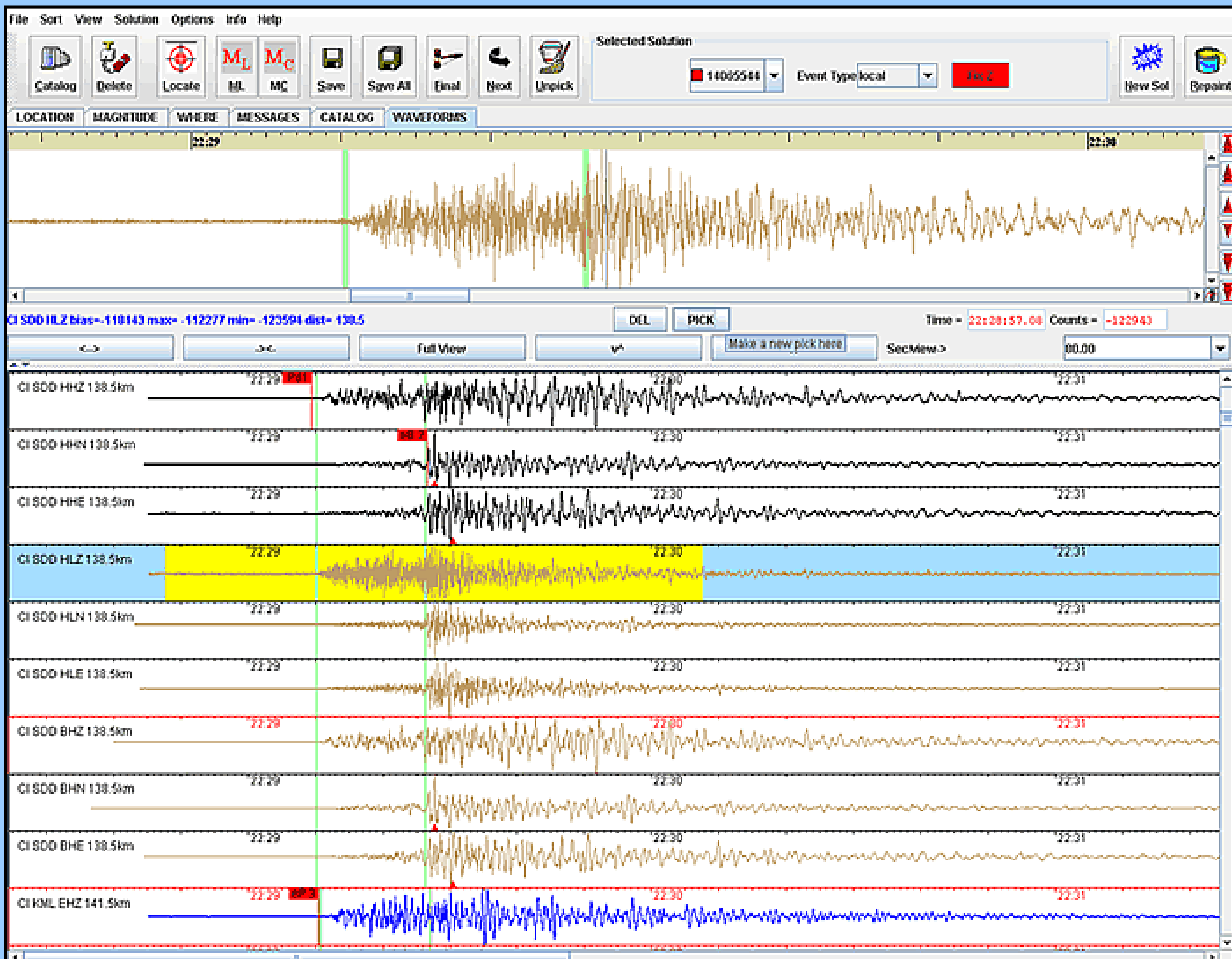
Introduction:

The Intricacies of the Seismic Network

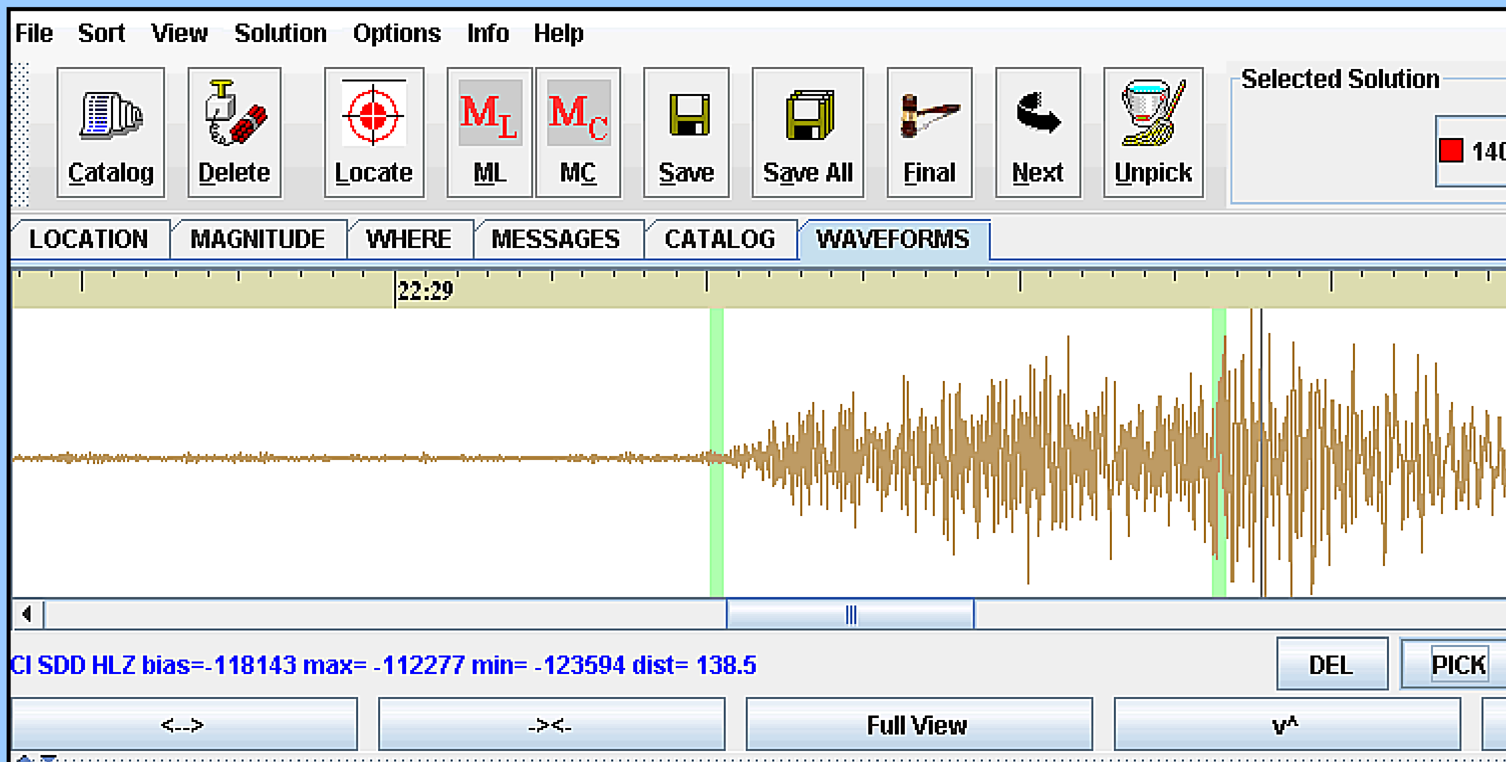
Advances in technology have made it possible to integrate separate earthquake monitoring networks into a single seismic system as well as to unify earthquake monitoring instrumentation. In California, this effort began in the south with the Tri Net Project. There Cal tech, the California Geological Survey (CGS), and the USGS combined efforts to create a unified seismic system for southern California. With major funding provided by the Federal Emergency Management Agency (FEMA), the California Governor's Office of Emergency Services (OES), and the USGS, the Tri Net project provided the opportunity to upgrade and expand the monitoring infrastructure, combining resources in a federal, state and university partnership. In 2000, the integration effort expanded to the entire State with the formation of the California Integrated Seismic Network (CISN). To this end, UC Berkeley and the USGS Menlo Park and Pasadena offices joined forces with Cal tech and the CGS.(Also, the Earthworm network data acquisition and processing system is the heart and sole of the system itself that allows specific departments , such as the DWR Earthquake Engineering , to connect to the system and share data. These agencies CGS, USGS, UC Berkeley do not use the same seismic data analysis software. Even though the use of Earthworm is paramount in sharing the data the actual analysis of the data uses different types of software. At DWR for example, the Seismic Analysis Code (SAC) is mainly use and no other agency uses this software. This is because SAC is old (Well over fifteen years) and out dated . the other agencies use what they see fit for their own analysis. For example, UC Berkeley uses Jiggle, which is basically an graphical earthquake analysis tool . The Nevada Seismological Laboratory(NSL) were DWR also shares seismic data with uses the the most expensive , but the most complete seismic analysis tool , called Antelope which is an real time seismic and environmental monitoring system. The extreme cost of this complex software is the primary reason to why DWR currently does not uses the Antelope software. However, plans in the future to call for a complete upgrade of the DWR earthquake engineering to change to a more robust system which includes acquiring the Antelope software. The need for a seismic network is off course is due to the state of California being the most prone to earthquakes and eventual catastrophic earthquakes with higher magnitudes that will cause considerable damage to states infrastructure as a whole and loss of life.

The following images are examples of seismic analysis tools used by seismologist:.

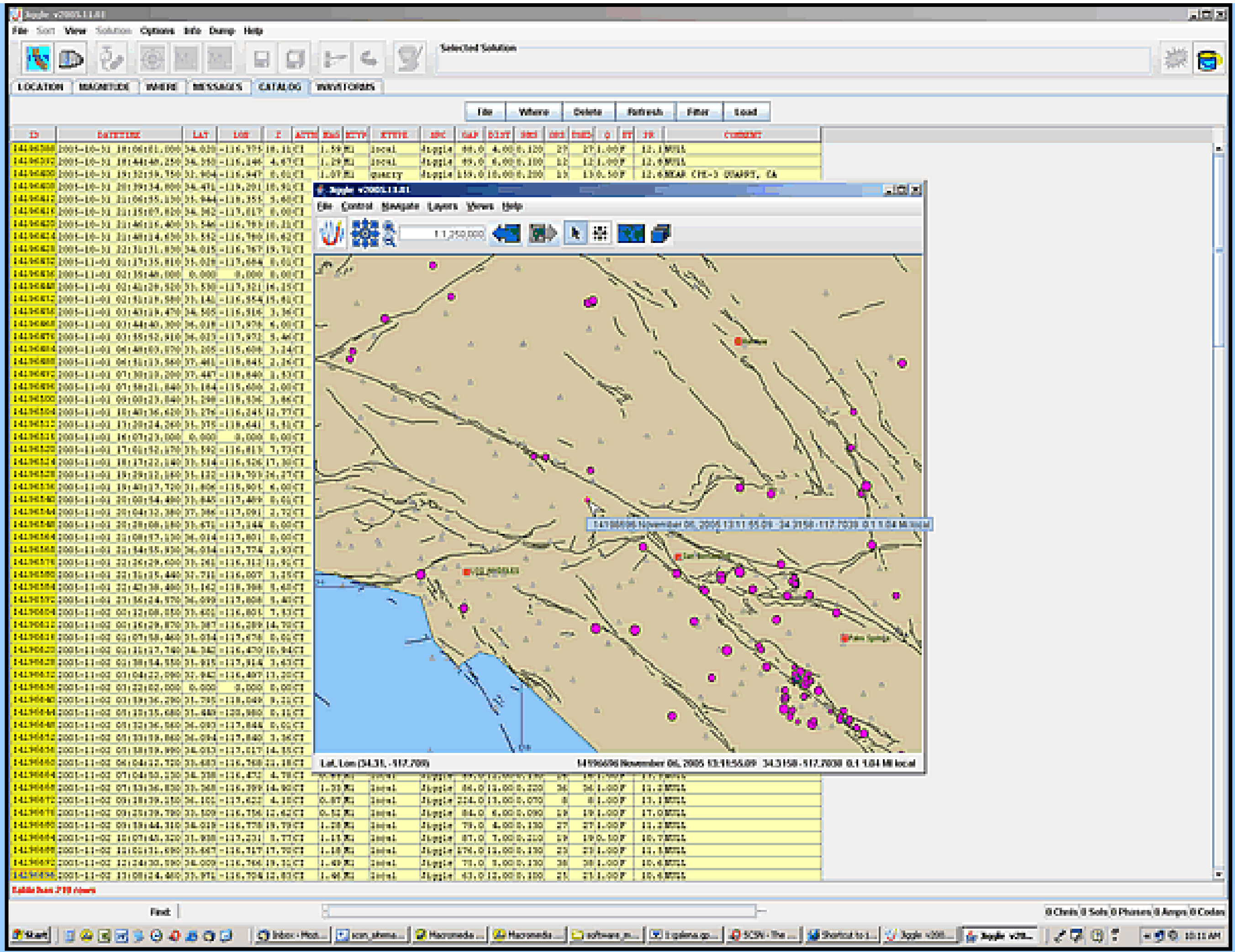
JIGGLE



This image shows the Jiggle earthquake analysis tool .



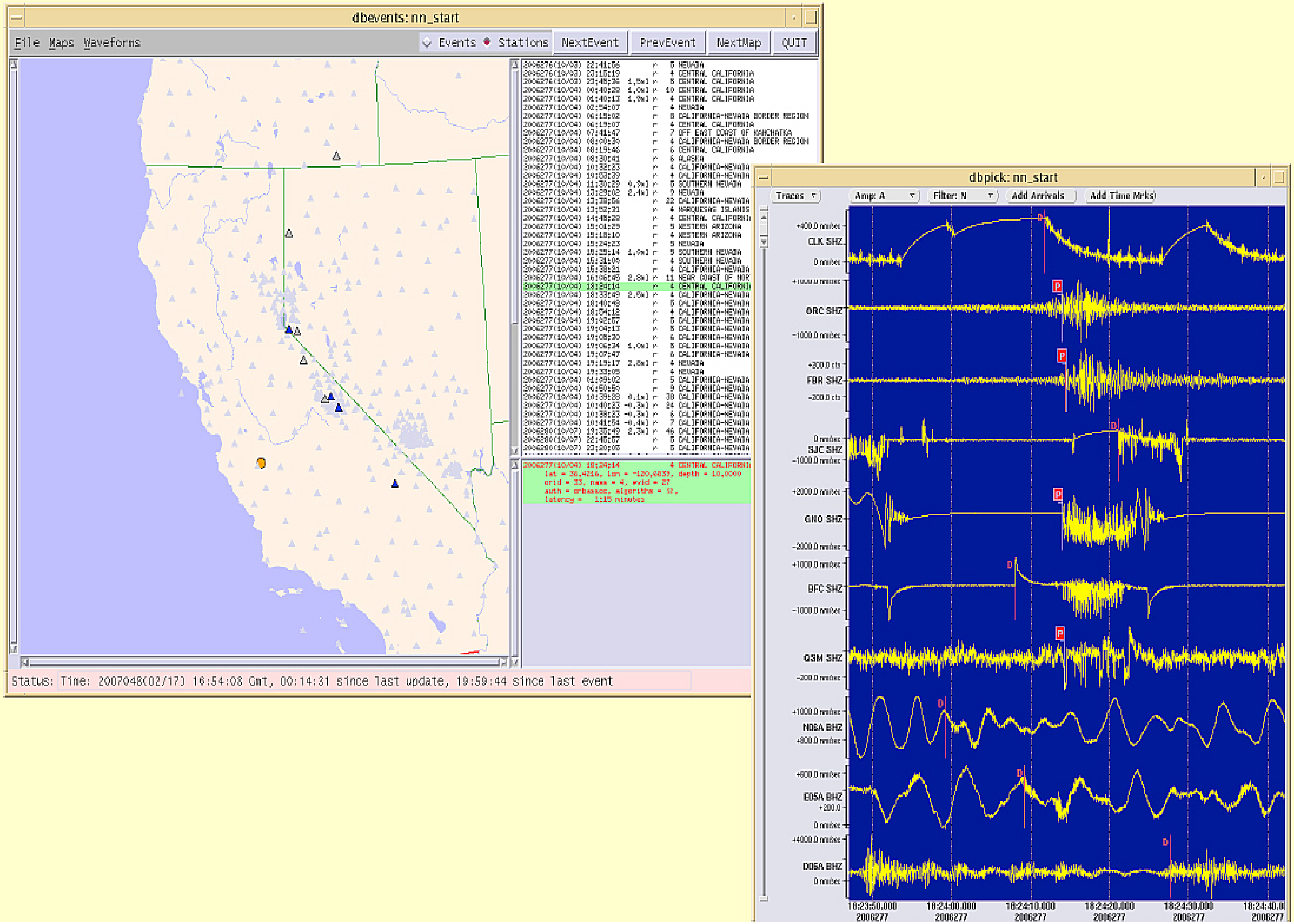
Another view of Jiggle which was developed by the USGS Pasadena Field Office Geophysicist, Doug Given.



This image shows one of key the features of Jiggle which also shows seismic stations, earthquake events, and faults. (Details)

ANTELOPE

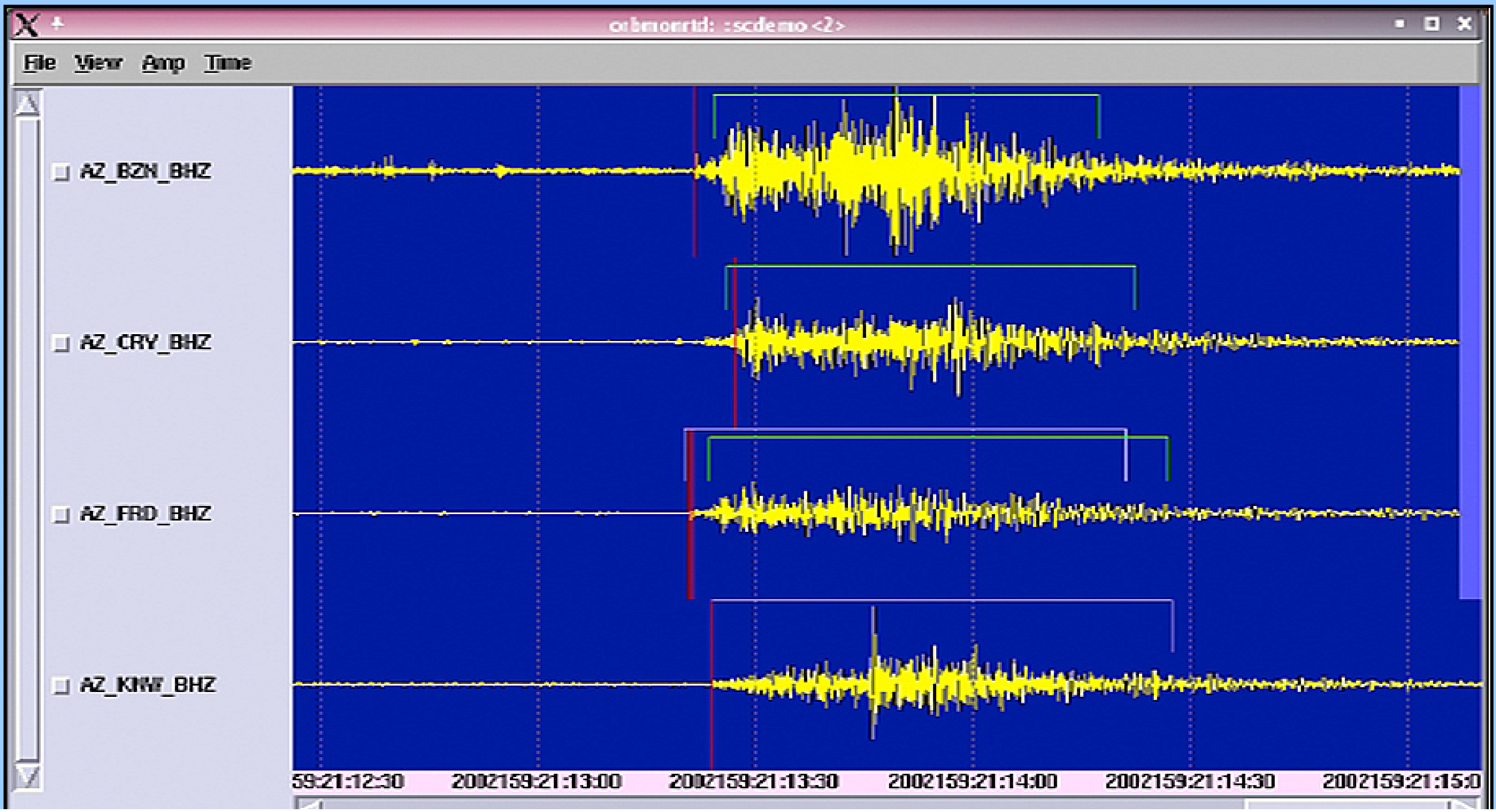
Mis-locations with small numbers of stations



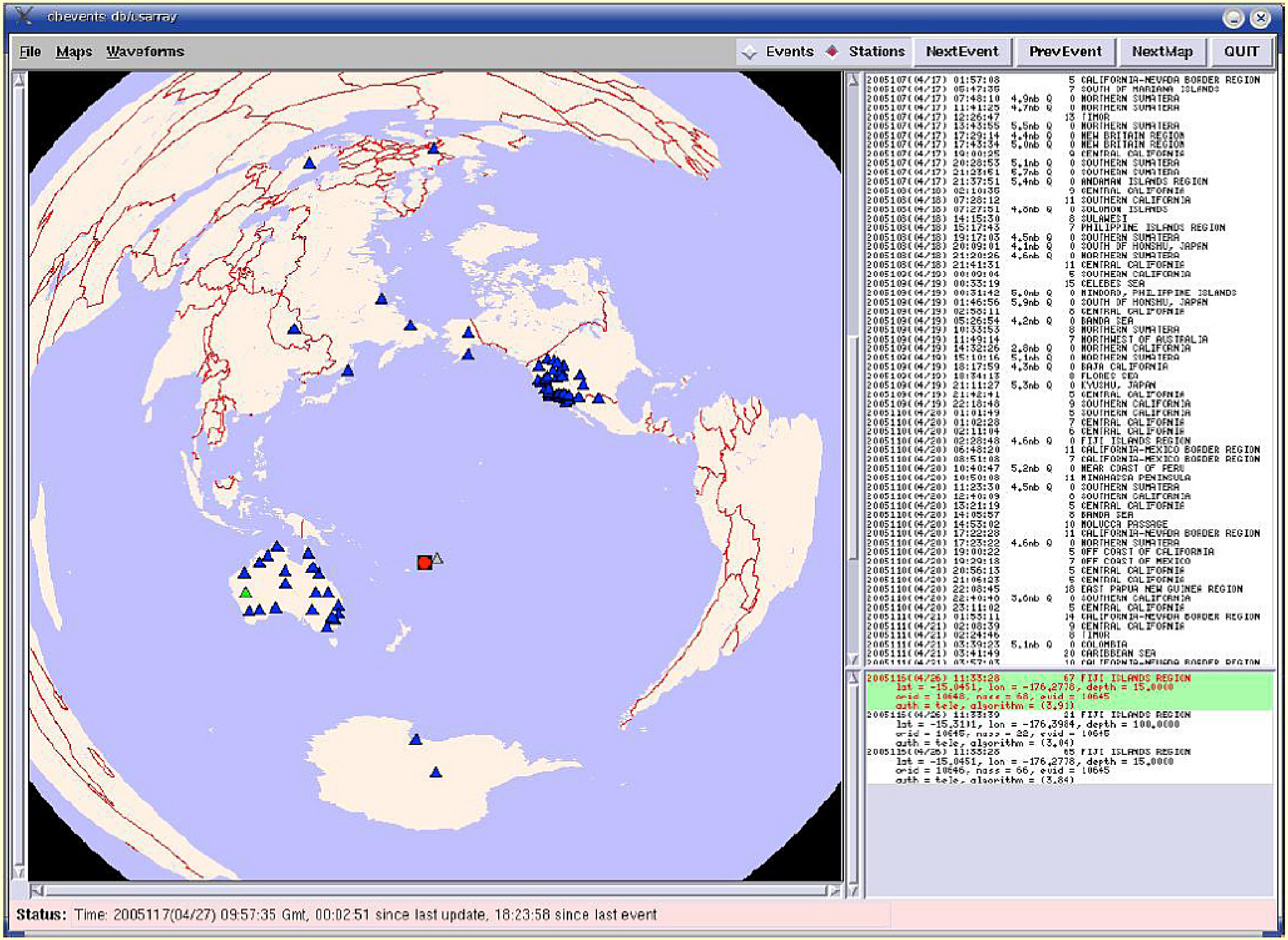
BRTT

February 2007

This image shows the Antelop seismic software with open application screens. (Details)



The Antelope seismic wave application window. (Details)

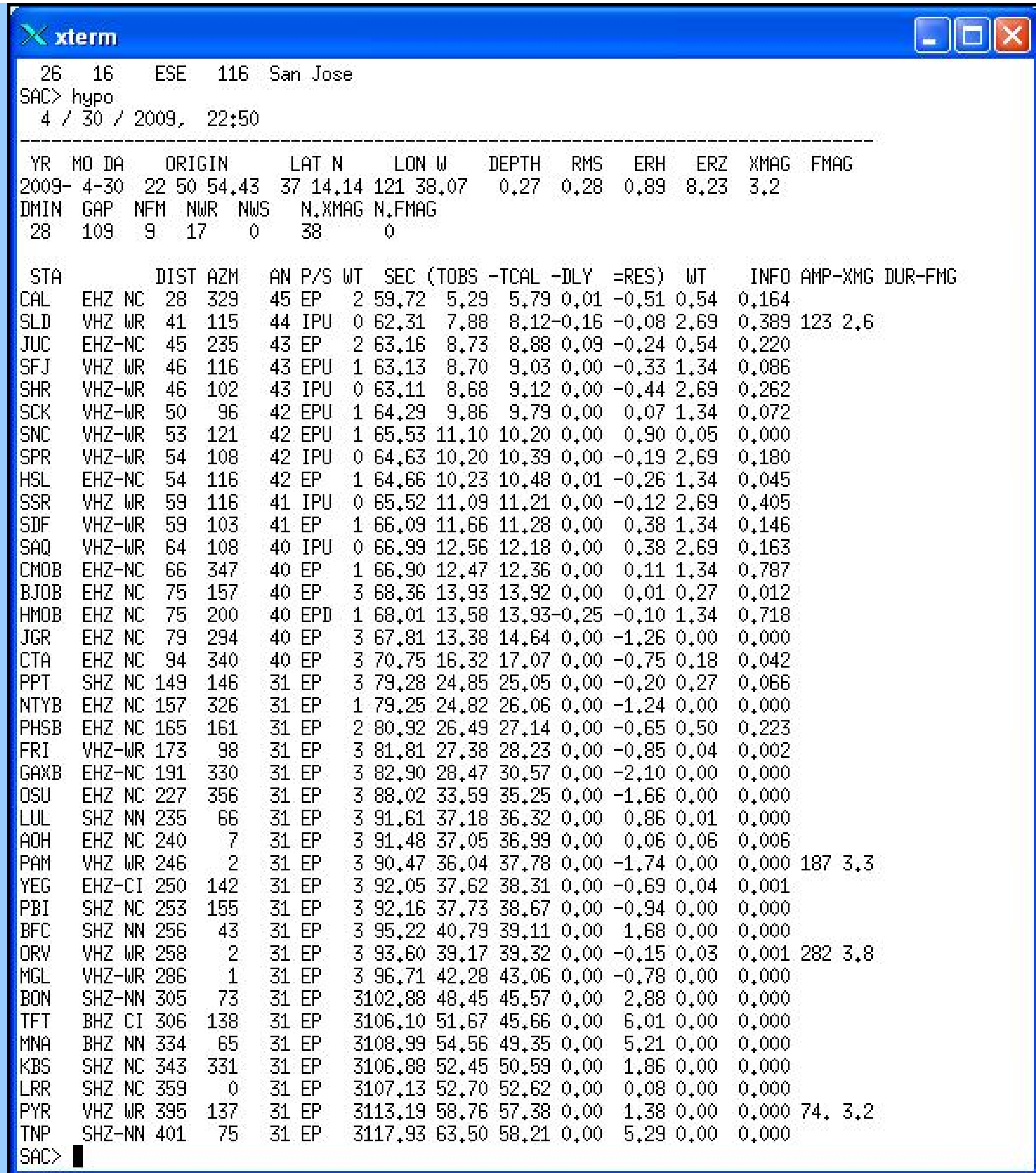


BRTT

February 2007

This image shows the global seismic analysis cabibility of the Antelope software . (Details)

SEISMIC ANALYSIS CODE (SAC)



```
xterm
  26   16    ESE   116  San Jose
SAC> hypo
  4 / 30 / 2009,  22:50
---------------------------------------------------------------------------------
 YR  MO DA   ORIGIN     LAT N     LON W    DEPTH   RMS   ERH   ERZ  XMAG  FMAG
2009- 4-30  22 50 54.43  37 14.14 121 38.07   0.27  0.28  0.89  8.23  3.2
DMIN  GAP  NFM  NWR  NWS   N.XMAG N.FMAG
 28   109   9   17    0    38      0

 STA         DIST AZM   AN P/S WT  SEC (TOBS -TCAL -DLY  =RES)  WT   INFO AMP-XMG DUR-FMG
CAL   EHZ NC  28  329   45 EP   2 59.72  5.29  5.79 0.01 -0.51 0.54  0.164
SLD   VHZ WR  41  115   44 IPU  0 62.31  7.88  8.12-0.16 -0.08 2.69  0.389 123 2.6
JUC   EHZ-NC  45  235   43 EP   2 63.16  8.73  8.88 0.09 -0.24 0.54  0.220
SFJ   VHZ WR  46  116   43 EPU  1 63.13  8.70  9.03 0.00 -0.33 1.34  0.086
SHR   VHZ-WR  46  102   43 IPU  0 63.11  8.68  9.12 0.00 -0.44 2.69  0.262
SCK   VHZ-WR  50   96   42 EPU  1 64.29  9.86  9.79 0.00  0.07 1.34  0.072
SNC   VHZ-WR  53  121   42 EPU  1 65.53 11.10 10.20 0.00  0.90 0.05  0.000
SPR   VHZ-WR  54  108   42 IPU  0 64.63 10.20 10.39 0.00 -0.19 2.69  0.180
HSL   EHZ-NC  54  116   42 EP   1 64.66 10.23 10.48 0.01 -0.26 1.34  0.045
SSR   VHZ WR  59  116   41 IPU  0 65.52 11.09 11.21 0.00 -0.12 2.69  0.405
SDF   VHZ-WR  59  103   41 EP   1 66.09 11.66 11.28 0.00  0.38 1.34  0.146
SAQ   VHZ-WR  64  108   40 IPU  0 66.99 12.56 12.18 0.00  0.38 2.69  0.163
CMOB  EHZ-NC  66  347   40 EP   1 66.90 12.47 12.36 0.00  0.11 1.34  0.787
BJOB  EHZ NC  75  157   40 EP   3 68.36 13.93 13.92 0.00  0.01 0.27  0.012
HMOB  EHZ NC  75  200   40 EPD  1 68.01 13.58 13.93-0.25 -0.10 1.34  0.718
JGR   EHZ NC  79  294   40 EP   3 67.81 13.38 14.64 0.00 -1.26 0.00  0.000
CTA   EHZ NC  94  340   40 EP   3 70.75 16.32 17.07 0.00 -0.75 0.18  0.042
PPT   SHZ NC 149  146   31 EP   3 79.28 24.85 25.05 0.00 -0.20 0.27  0.066
NTYB  EHZ NC 157  326   31 EP   1 79.25 24.82 26.06 0.00 -1.24 0.00  0.000
PHSB  EHZ NC 165  161   31 EP   2 80.92 26.49 27.14 0.00 -0.65 0.50  0.223
FRI   VHZ-WR 173   98   31 EP   3 81.81 27.38 28.23 0.00 -0.85 0.04  0.002
GAXB  EHZ-NC 191  330   31 EP   3 82.90 28.47 30.57 0.00 -2.10 0.00  0.000
OSU   EHZ NC 227  356   31 EP   3 88.02 33.59 35.25 0.00 -1.66 0.00  0.000
LUL   SHZ NN 235   66   31 EP   3 91.61 37.18 36.32 0.00  0.86 0.01  0.000
AOH   EHZ NC 240    7   31 EP   3 91.48 37.05 36.99 0.00  0.06 0.06  0.006
PAM   VHZ WR 246    2   31 EP   3 90.47 36.04 37.78 0.00 -1.74 0.00  0.000 187 3.3
YEG   EHZ-CI 250  142   31 EP   3 92.05 37.62 38.31 0.00 -0.69 0.04  0.001
PBI   SHZ NC 253  155   31 EP   3 92.16 37.73 38.67 0.00 -0.94 0.00  0.000
BFC   SHZ NN 256   43   31 EP   3 95.22 40.79 39.11 0.00  1.68 0.00  0.000
ORV   VHZ WR 258    2   31 EP   3 93.60 39.17 39.32 0.00 -0.15 0.03  0.001 282 3.8
MGL   VHZ-WR 286    1   31 EP   3 96.71 42.28 43.06 0.00 -0.78 0.00  0.000
BON   SHZ-NN 305   73   31 EP   3102.88 48.45 45.57 0.00  2.88 0.00  0.000
TFT   BHZ CI 306  138   31 EP   3106.10 51.67 45.66 0.00  6.01 0.00  0.000
MNA   BHZ NN 334   65   31 EP   3108.99 54.56 49.35 0.00  5.21 0.00  0.000
KBS   SHZ NC 343  331   31 EP   3106.88 52.45 50.59 0.00  1.86 0.00  0.000
LRR   SHZ NC 359    0   31 EP   3107.13 52.70 52.62 0.00  0.08 0.00  0.000
PYR   VHZ WR 395  137   31 EP   3113.19 58.76 57.38 0.00  1.38 0.00  0.000 74. 3.2
TNP   SHZ-NN 401   75   31 EP   3117.93 63.50 58.21 0.00  5.29 0.00  0.000
SAC>
```

This image shows a open window of one of many tool applications created by SAC.

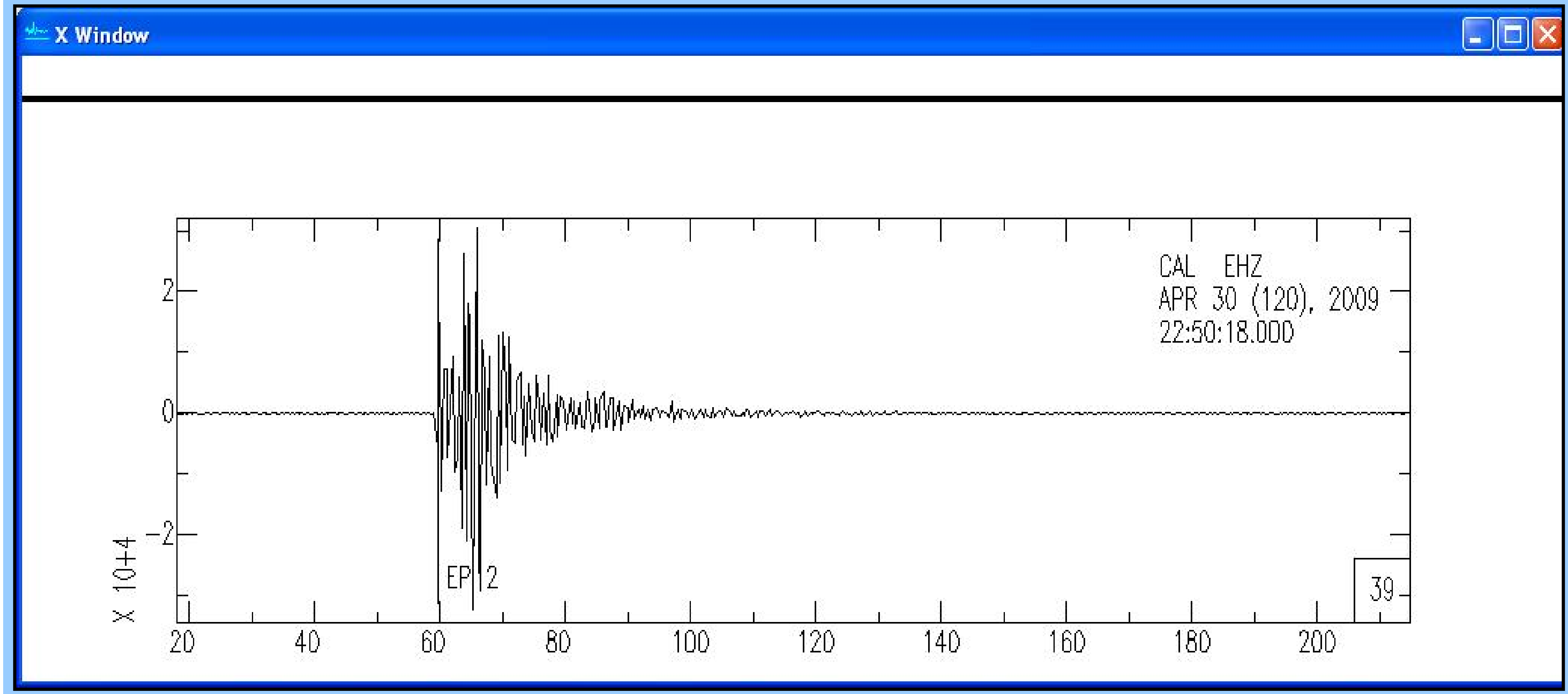
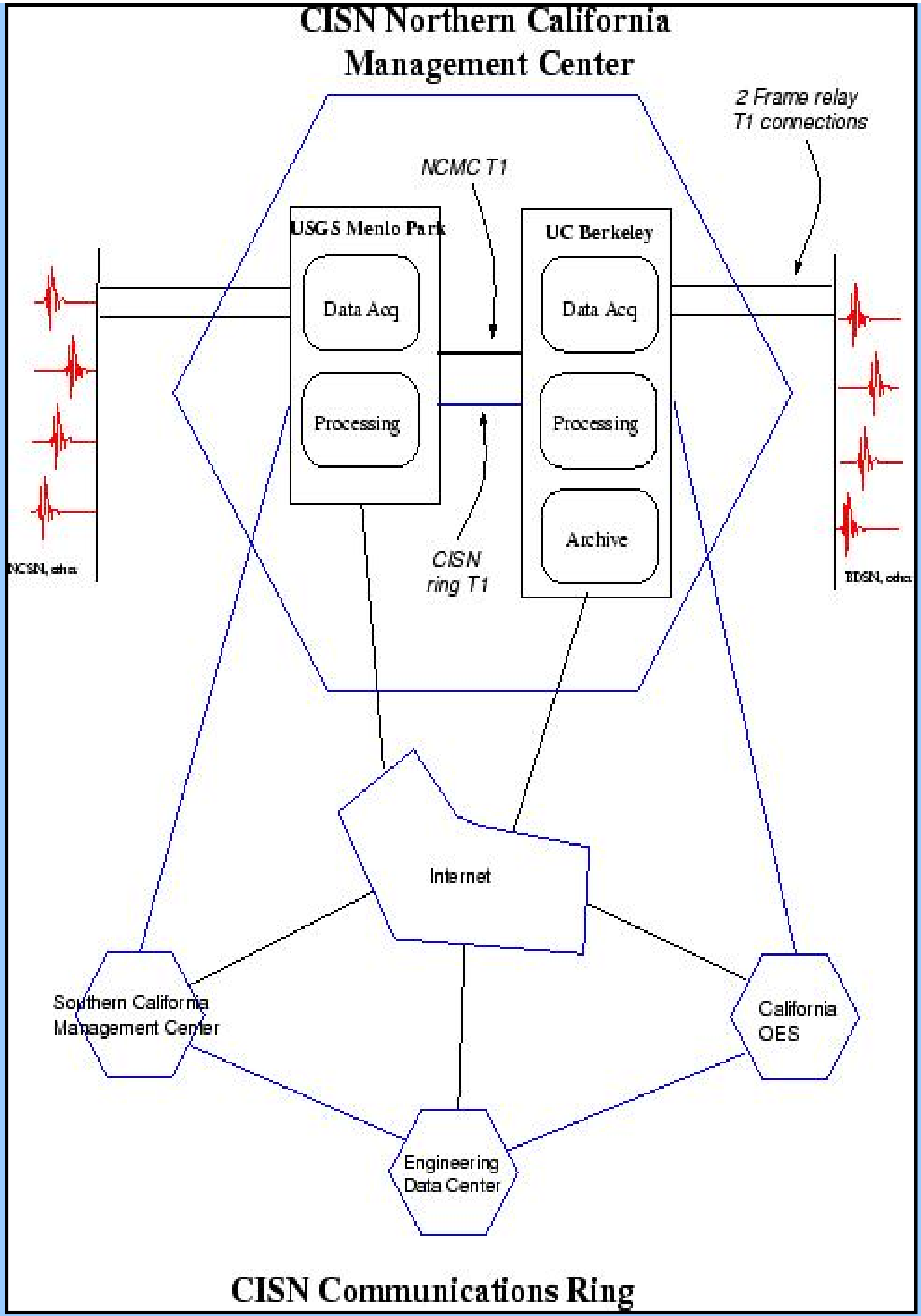


Image of a quake which was recorded by a seismic station owned by DWR.

Background:

The complex CISN organizational system started as an effective means to coordinate the monitoring of earthquakes in California. This organization consist of three main management centers which are Southern California Earthquake Management Center: Cal tech/USGS Pasadena Northern California Earthquake Management Center: UC Berkeley/USGS Menlo Park Engineering Strong Motion Data Center: California Geological Survey/USGS National Strong Motion Program . the Northern California earthquake centers have two other agencies that manifest earthquake data analysis that primary deals with strong motion data which is produced by earthquakes at higher levels.(Strong-motion seismology and ground motion, USGS). The California Strong Motion Instrumentation Program (CSMIP) is the primary state agency that specifically deals with the analysis of strong motion data. The other organizations contribute data that enhances the capabilities of the CISN. Contributing members include: University of California, Santa Barbara; University of California, San Diego; University of Nevada, Reno; University of Washington; California Department of Water Resources; Lawrence Livermore National Lab; and Pacific Gas and Electric.



"Schematic diagram illustrating the connectivity between the real-time processing systems at the USGS Menlo Park and UC Berkeley, forming the Northern

California Management Center, and with other elements of the CISN". (CISN communication system)

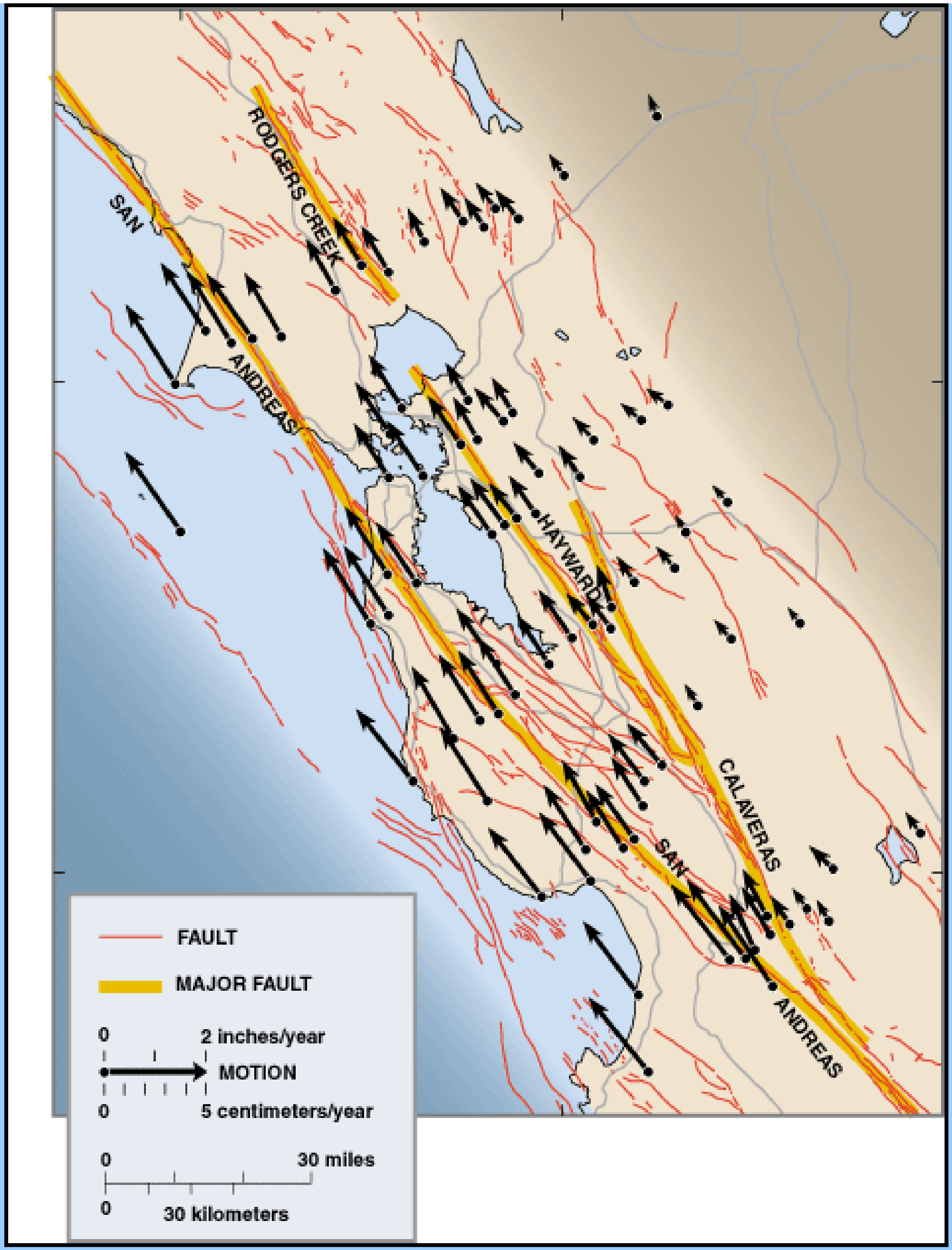
Methods :

Most of the data used to find information for this report were all on the internet. Majority of all the explanations about the CISN network are displayed on web sites and all are free for download . Most web sites such as the USGS, CISN , SCSN , CGS, Cal tech , OES, BSL, and DWR have significant information about earthquakes and how the data is used for the specific projects , either by collaboration or by themselves. The web sites provided in the references had considerable information regarding who the seismic network works and how in the future will continue to expand. Considering that I work at the DWR Earthquake Engineering and analyze earthquake data and also involved expanding our own seismic network which will contribute more capability to the CISN network , made me understand even more how I was a major contributor to the CISN network and how my own analysis of earthquakes by locating them, contributes more data to the seismological society .

Results :

The following understanding of the earthquake hazards in the bay area region was founded on the USGS web site. The analysis shows how different agencies in California are able to communicate with each other and how the improvements in technology itself and the seismic network can save thousands of lives in case a major earthquake were to course. The images below concentrate on the region of study and the motion of major faults in the bay area region and the need for an expansion of the current seismic network that can not only warn specific agencies , such as Department of Water Resources of a earthquake and give specific information (Magnitude, location) about the quake over the internet but share data with specific agencies to respond accordingly in case a major earthquake were to occur. In addition , other diagrams and pictures examine the use of shake maps , probability of future earthquakes in the bay area and information on the active faults in Southern California and the threat they pose on the Southern region were the population is dense. Also, additional views of current earthquake notification software used by different agencies is also shown.

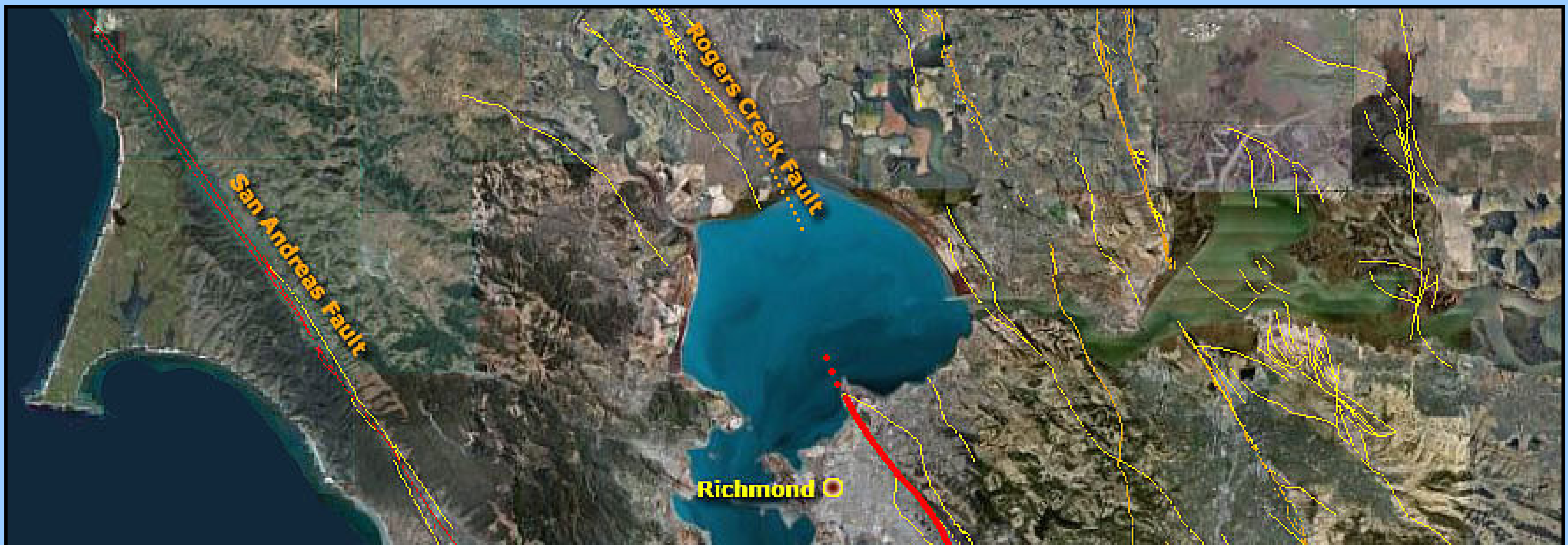
"Since the Loma Prieta shock, the U.S. Geological Survey (USGS) and cooperating organizations have intensified efforts to understand earthquake hazards and apply this new knowledge to reducing future losses. Greater attention has been focused on the Nation's urban regions threatened by strong earthquakes, because these areas have the most people at risk, the largest inventory of structures, and the densest and most complex infrastructure. Communication of earthquake-hazard information to the public and to those in business and government responsible for decisions and actions has also been strengthened. The following paragraphs highlight advances and accomplishments of these efforts in the San Francisco Bay region since the 1989 earthquake". (San Francisco Bay region)



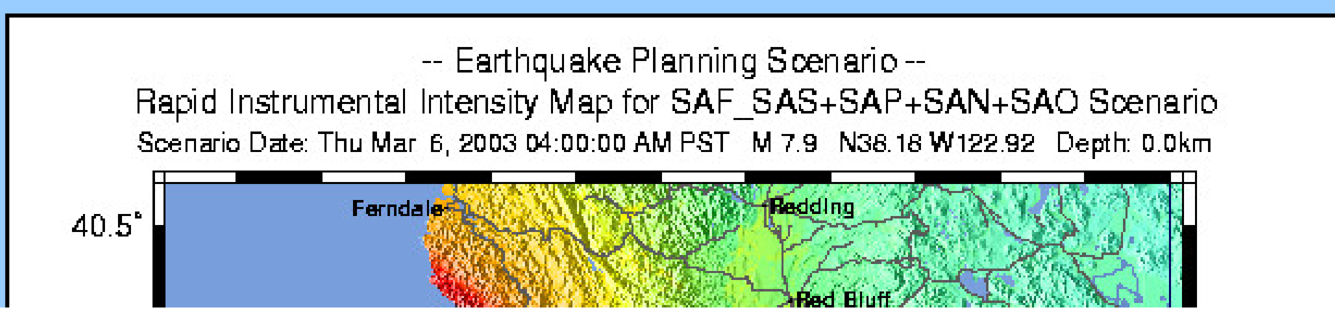
"The San Francisco Bay region lies on the boundary zone between two of the major tectonic plates that make up the Earth's outer shell. The continuous motion between the Pacific and North American Plates, distributed across this zone, is monitored by geophysicists using the satellite-based Global Positioning System (GPS). Arrows on this map depict recent (mid to late 1990's) rates of movement, relative to the interior of the North American Plate, of reference markers anchored in rock or deep in solid ground. This relentless motion of the plates strains the crustal rocks of the Bay region, storing energy that eventually will be released in earthquakes. During the time represented in this

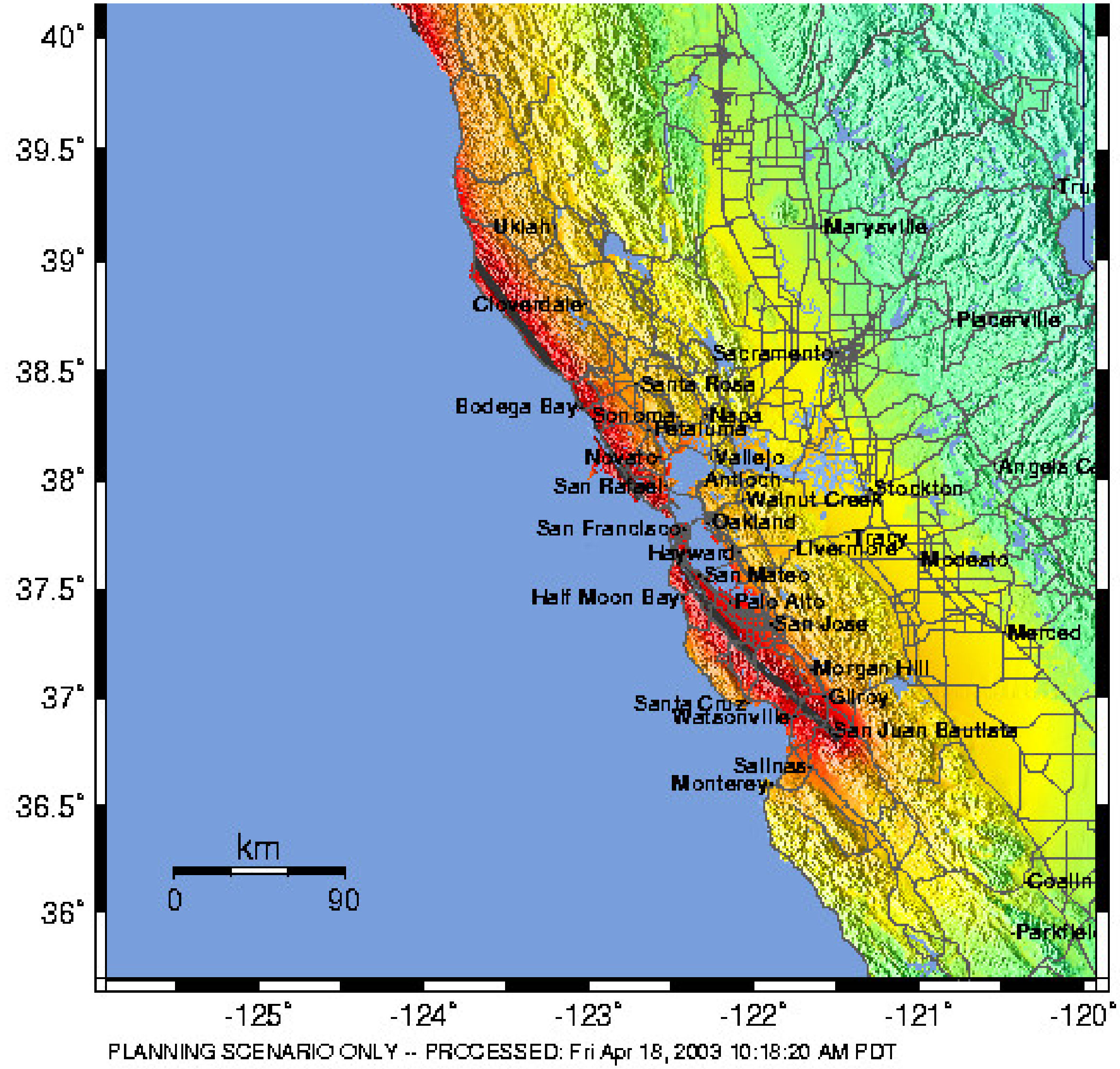
diagram, most of the faults in the Bay region have been "locked," not producing earthquakes".(Earthquake Probabilities)

"Modern computer technology allows wide access to authoritative information about an earthquake immediately after its occurrence. Computers at the USGS and the University of California at Berkeley (UCB) have for some years automatically posted information for northern California shocks on the World Wide Web. In 1996, when a magnitude 4.7 shock struck the San Francisco Bay region, the great demand for information overwhelmed the capacity of the Web site. The site has been continually upgraded, and its capacity expanded. Currently, a location map is usually posted on the site within 1 minute of a widely felt earthquake, and the magnitude within 5 minutes (http://quake.usgs.gov/recenteqs/). When a magnitude 5.0 quake occurred beneath Bolinas in mid-August 1999, more than 30,000 users were able to access this Web site in the first hour after the quake struck. The USGS, CDMG, UCB, and PG&E are cooperating to add information on the severity of ground shaking to the web site. As of fall 1999, maps showing the pattern of shaking measured across the region can be posted within tens of minutes of broadly felt earthquakes. Quick access to information on ground shaking will be of particular value in the Bay region, where the wide variety of geologic materials„from hard bedrock to soft clay„causes large differences in shaking intensity. This information will help emergency-response officials to identify locations where damage and need are likely to be greatest. In past quakes, identifying such locations has too often been delayed by disrupted communications. As a result, the initial picture of the earthquake's effects has often been seriously incomplete." (Earthquake information)



Map showing the active earthquake faults in the bay area region.





PERCEIVED SHAKING	Not felt	Weak	Light	Moderate	Strong	Very strong	Severe	Violent	Extreme
POTENTIAL DAMAGE	none	none	none	Very light	Light	Moderate	Moderate/Heavy	Heavy	Very Heavy
PEAK ACC.(%g)	<.17	.17-1.4	1.4-3.9	3.9-9.2	9.2-18	18-34	34-65	65-124	>124
PEAK VEL.(cm/s)	<0.1	0.1-1.1	1.1-3.4	3.4-8.1	8.1-16	16-31	31-60	60-116	>116
INSTRUMENTAL INTENSITY	I	II-III	IV	V	VI	VII	VIII	IX	X+

Intensity Shake Map, scenario of a 7.9 magnitude earthquake occurring in the bay area region. (**Earthquake planning scenario**)

Magnitude	*San Francisco region**	*Los Angeles region*
6.7	*63%*	*67%*
Magnitude	*Northern California***	*Southern California*
6.7	*93%*	*97%*
7	*68%*	*82%*
7.5	*15%*	*37%*
8	*2%*	*3%*
**Probabilities from UCERF for the San Francisco region are nearly identical to the previous results from WGCEP 2003. **These probabilities do not include the Cascadia Subduction Zone*		

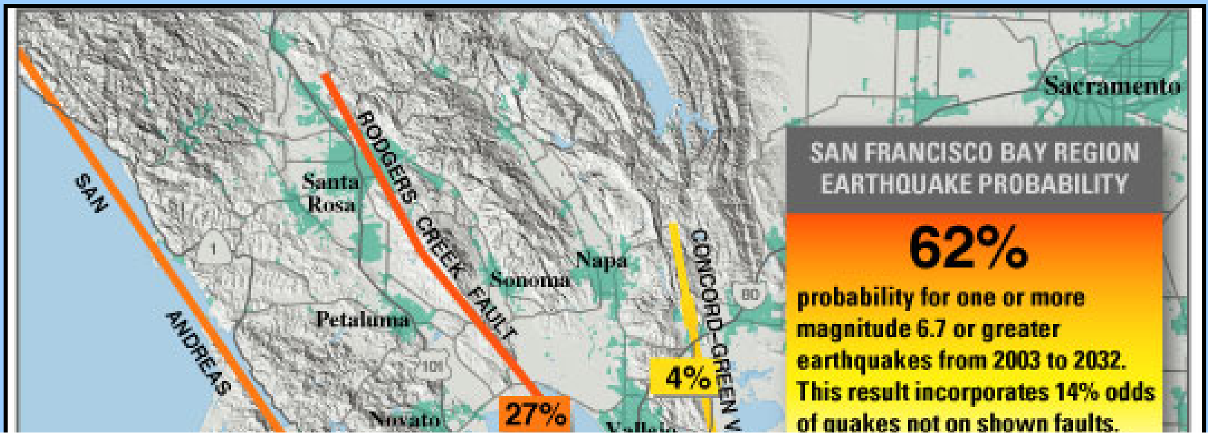
This diagram incorporates the 30- year earthquake probabilities. ([Forecasting California Quakes])

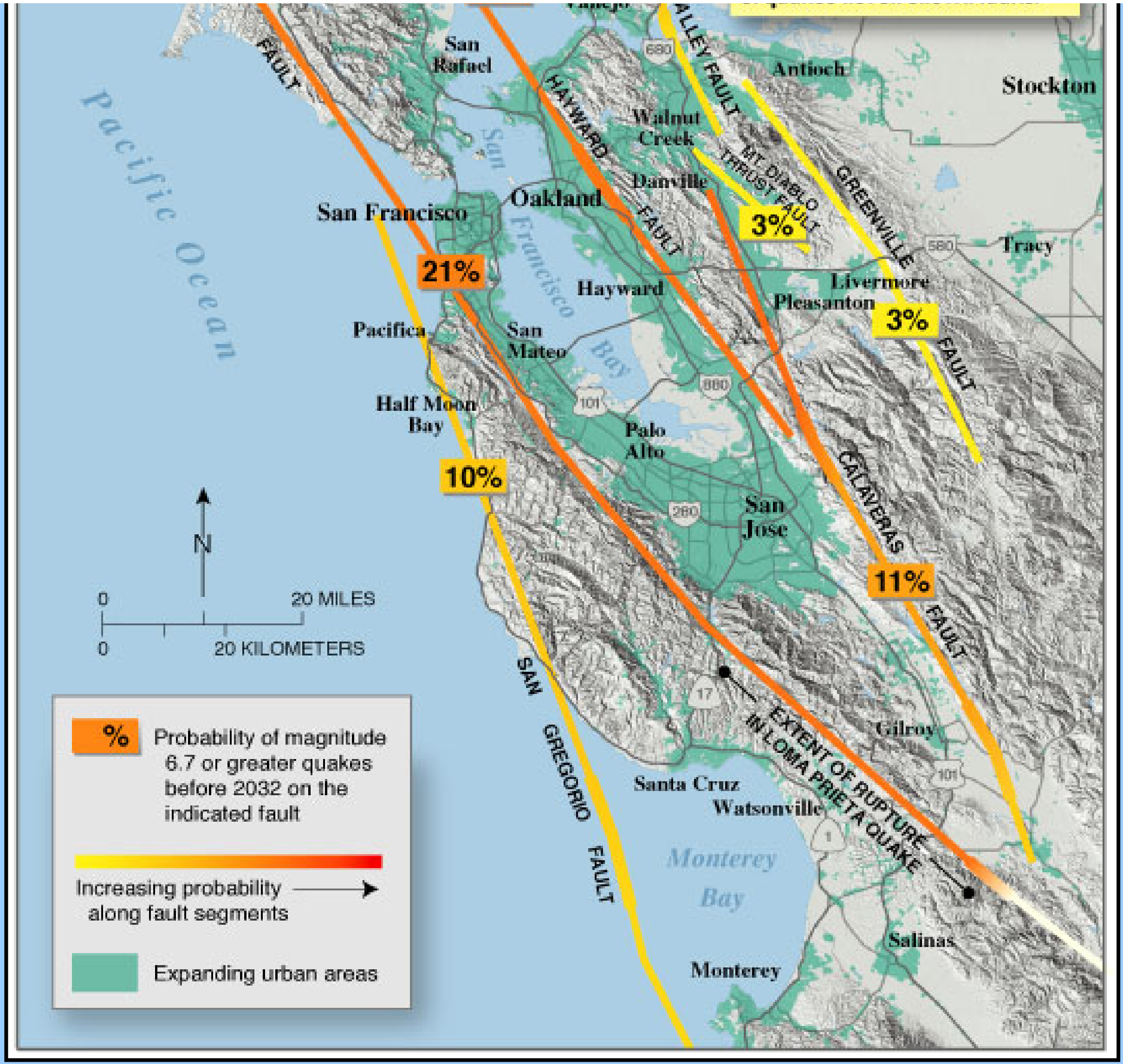
Fault	*Probability of one or more magnitude 6.7 or greater quake*
Southern San Andreas	*59%*
Hayward-Rodgers Creek	*31%*
San Jacinto	*31%*
Northern San Andreas	*21%*
Elsinore	*11%*
Calaveras	*7%*
Garlock	*6%*

This diagram indicates the study done by [UCERF] of earthquake faults causing a major earthquake in the next 30-years. ([Forecasting California Quakes])

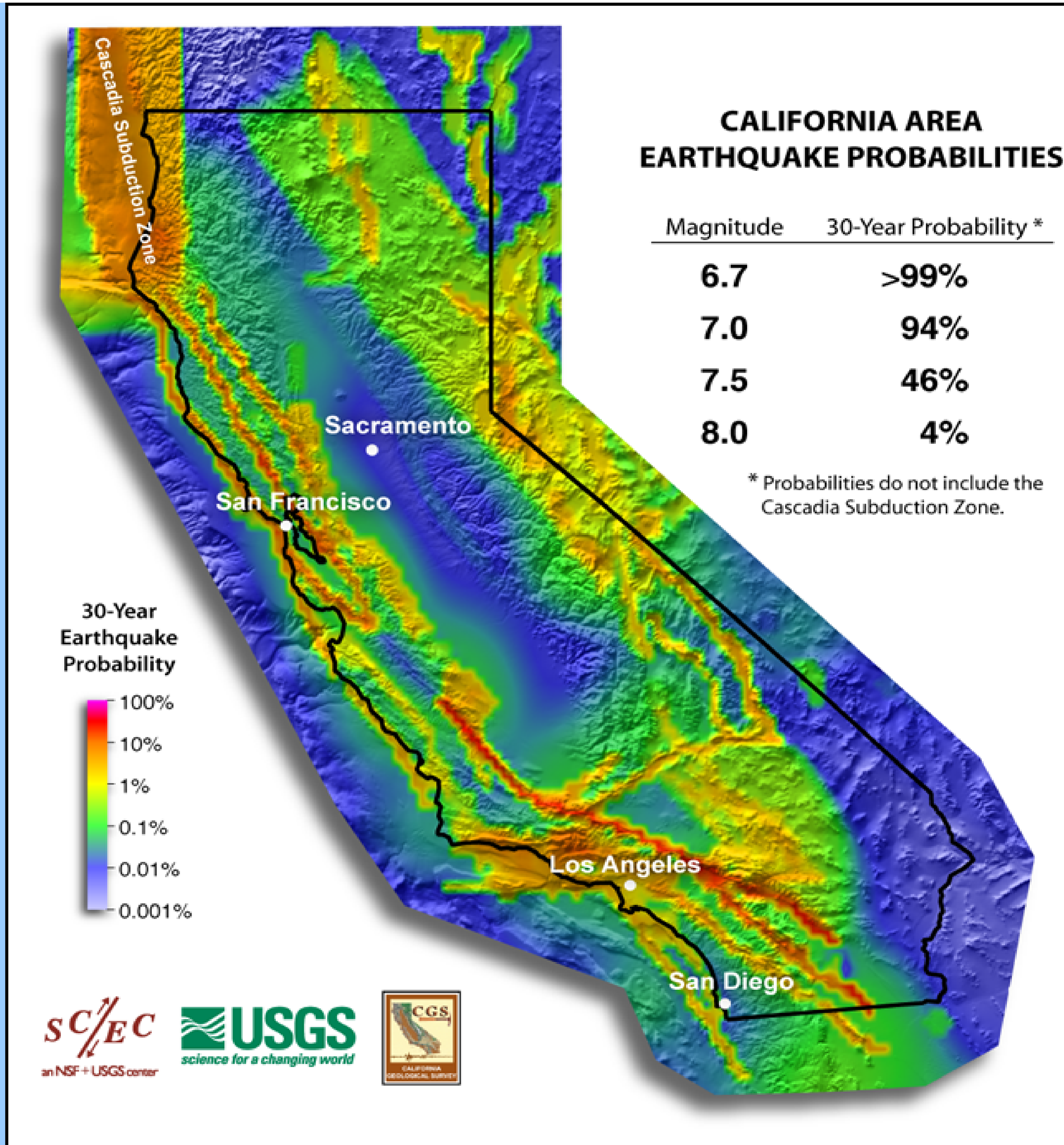
Magnitude	*30-year probability of one or more events greater than or equal to the magnitude*	*Average repeat time (years)*
6.7	*>99%*	*5*
7	*94%*	*11*
7.5	*46%*	*48*
8	*4%*	*650*
**Not including [Cascadia Subduction Zone](#)*		

This diagram shows the probabilities of a major earthquake occurring within the State of California .([Forecasting California Quakes](#))



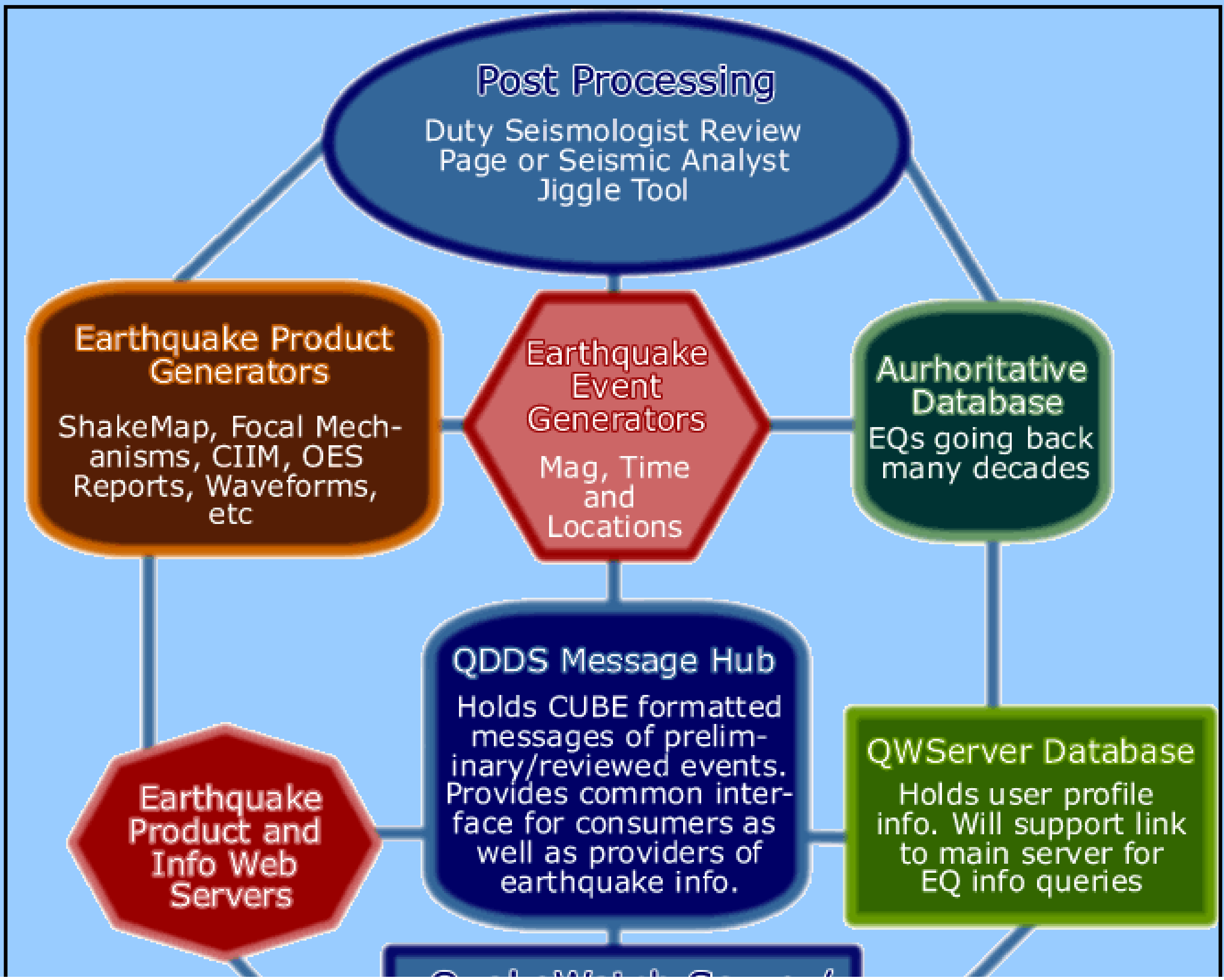


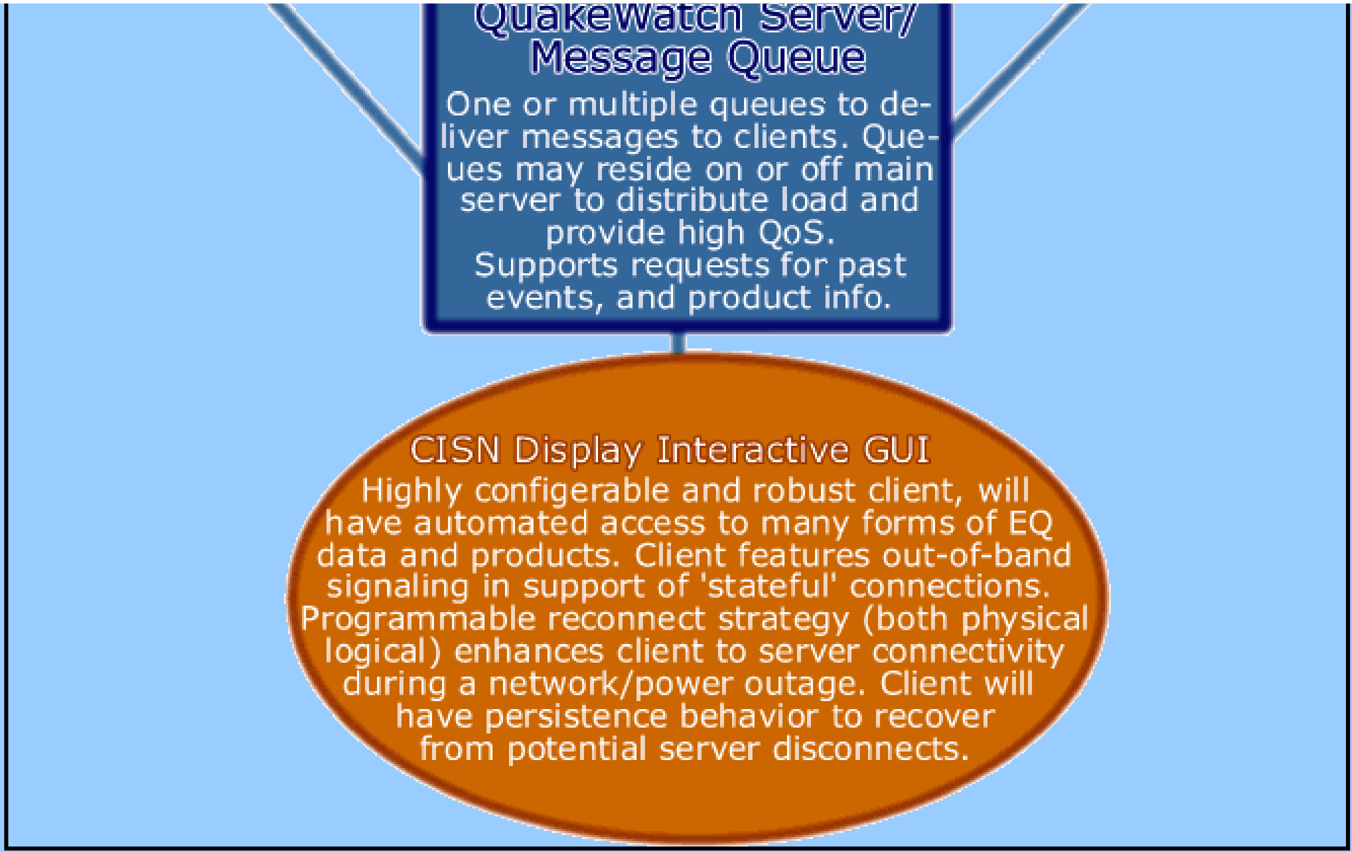
Map showing the probability of a earthquake occurring in the bay area region from 2003 to 2032. (CISN working group)


CALIFORNIA AREA
EARTHQUAKE PROBABILITIES
Magnitude
30-Year Probability *
6.7 >99%
7.0 94%
7.5 46%
8.0 4%
* Probabilities do not include the Cascadia Subduction Zone.
Cascadia Subduction Zone
Sacramento
San Francisco
Los Angeles
San Diego
30-Year Earthquake Probability
100%
10%
1%
0.1%
0.01%
0.001%
an NSF + USGS center
USGS
science for a changing world

Map showing the probability of a magnitude 6.7 quake occurring in the next 30 years. A magnitude 7.5 may quake may occur in the same time frame.

(The 2007 Working Group on California Earthquake Probabilities (WGCEP 2007))

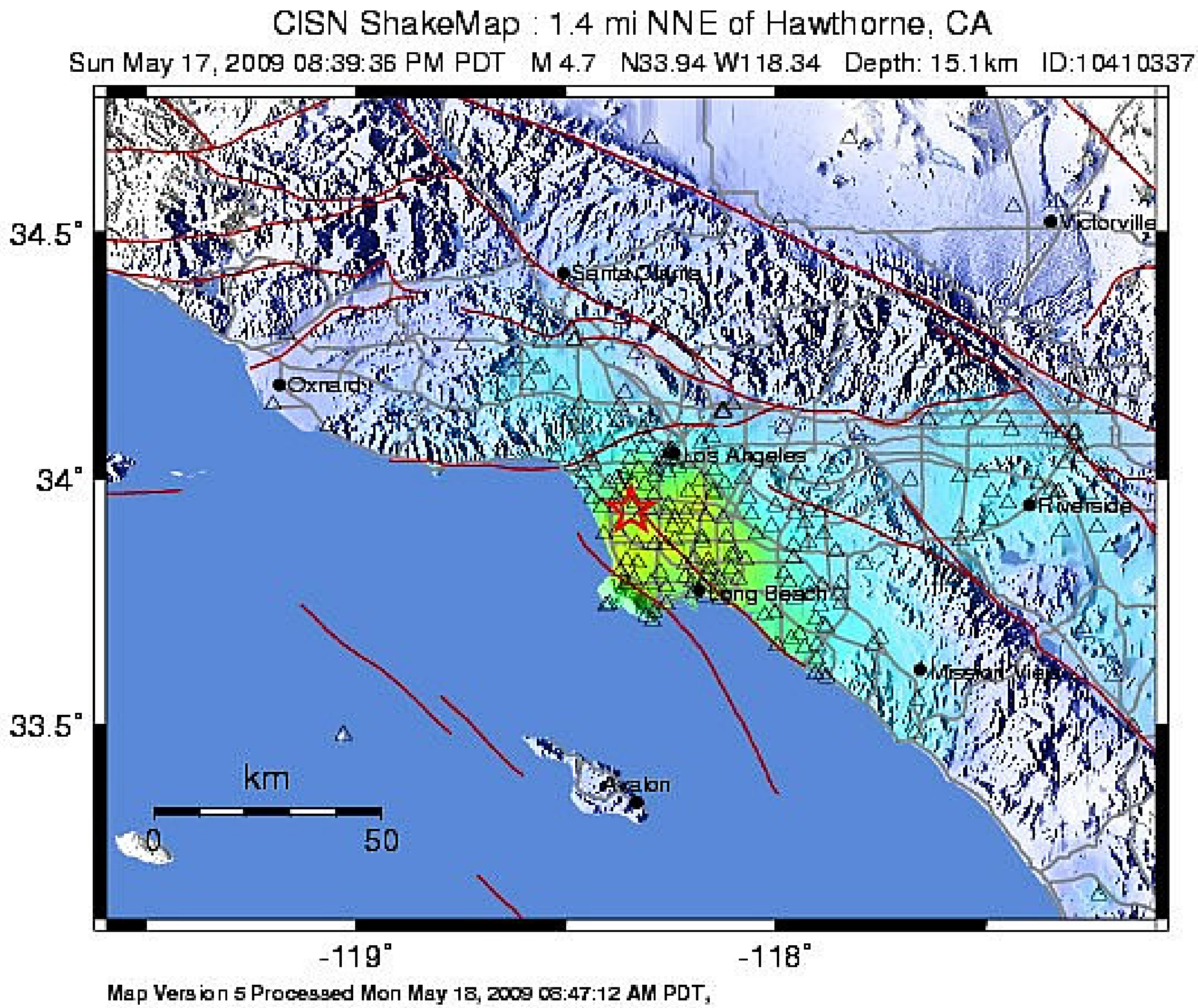




This diagram shows how the CISN display sends critical seismic data and information to all the state agencies that are part of the network .

(CISN Display)

[Webcast CISN Display Demonstration]()



PERCEIVED SHAKING	Not felt	Weak	Light	Moderate	Strong	Very strong	Severe	Violent	Extreme
POTENTIAL DAMAGE	none	none	none	Very light	Light	Moderate	Moderate/Heavy	Heavy	Very Heavy
PEAK ACC.(%g)	<.17	.17-1.4	1.4-3.9	3.9-9.2	9.2-18	18-34	34-65	65-124	>124
PEAK VEL.(cm/s)	<0.1	0.1-1.1	1.1-3.4	3.4-8.1	8.1-16	16-31	31-60	60-116	>116
INSTRUMENTAL INTENSITY	I	II-III	IV	V	VI	VII	VIII	IX	X+

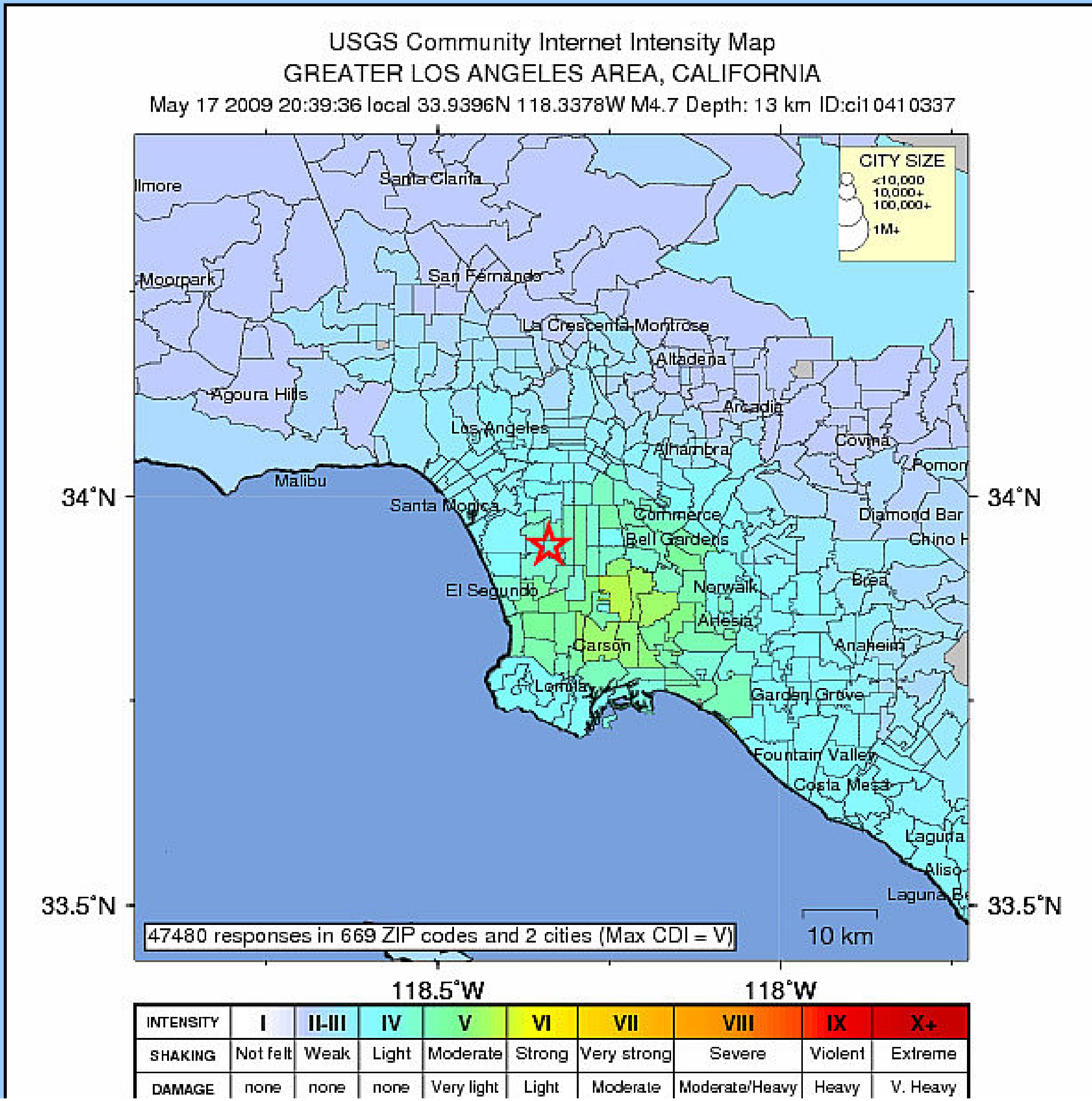
Example of a shake map generated by CISN of the most recent quake in Southern California.

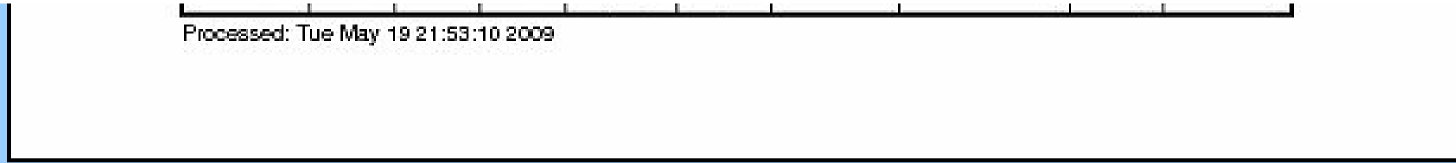
(Magnitude 4.7 - GREATER LOS ANGELES AREA, CALIFORNIA , (2009 May 18 03:39:36 UTC)

Earthquake Details

Magnitude	*4.7*
Date-Time	• *Monday, May 18, 2009 at 03:39:36 UTC* • *Sunday, May 17, 2009 at 08:39:36 PM at epicenter* • *Time of Earthquake in other Time Zones*
Location	*33.937°N, 118.345°W*
Depth	*15.1 km (9.4 miles)*
Region	*GREATER LOS ANGELES AREA, CALIFORNIA*
Distances	• *1 km (1 miles) ESE (107°) from Lennox, CA* • *2 km (1 miles) N (8°) from Hawthorne, CA* • *2 km (1 miles) S (178°) from Inglewood, CA* • *6 km (4 miles) ENE (73°) from El Segundo, CA* • *16 km (10 miles) SW (215°) from Los Angeles Civic Center, CA*
Location Uncertainty	*horizontal +/- 0.2 km (0.1 miles); depth +/- 0.3 km (0.2 miles)*
Parameters	*Nph=189, Dmin=6 km, Rmss=0.44 sec, Gp= 43°,* *M-type=centroid moment magnitude (Mw), Version=S*
Source	• *California Integrated Seismic Net:* • *USGS Caltech CGS UCB UCSD UNR*
Event ID	*ci10410337*

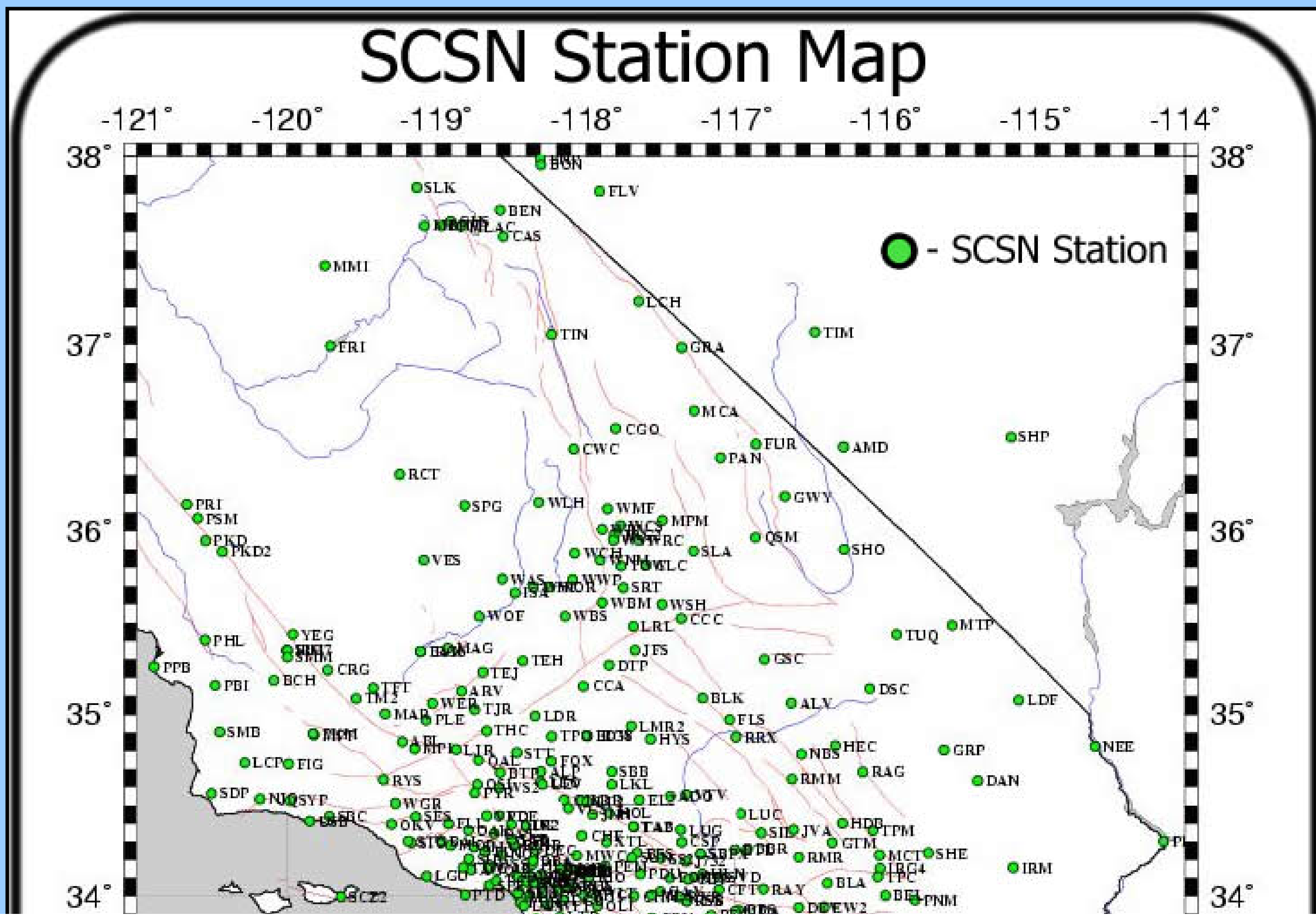
Example of the earthquake data generated by USGS report and send by e mail to all agencies.

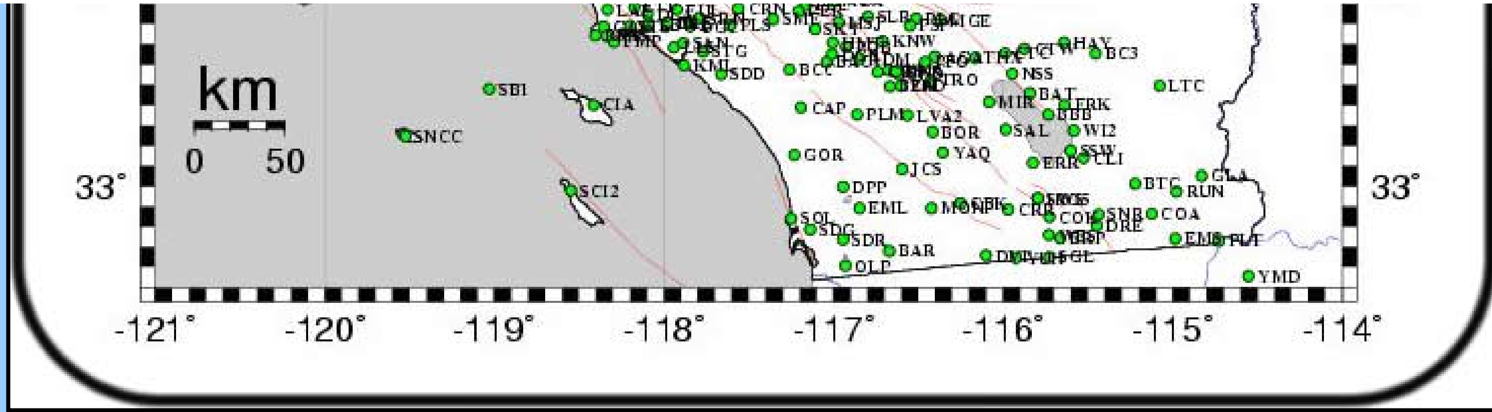

USGS Community Internet Intensity Map
GREATER LOS ANGELES AREA, CALIFORNIA
May 17 2009 20:39:36 local 33.9396N 118.3378W M4.7 Depth: 13 km ID:ci10410337
CITY SIZE
<10,000
10,000+
100,000+
1M+
llmore
Santa Clarita
Moorpark
San Fernando
La Crescenta-Montrose
Altadena
Agoura Hills
Arcadia
Los Angeles
Alhambra
Covina
Pomon
Malibu
Santa Monica
Commerce
Diamond Bar
Bell Gardens
Chino H
Brea
El Segundo
Norwalk
Artesia
Carson
Anaheim
Lomita
Garden Grove
Fountain Valley
Costa Mesa
Laguna
Aliso
Laguna Be
34°N
33.5°N
118.5°W
118°W
47480 responses in 669 ZIP codes and 2 cities (Max CDI = V)
10 km
INTENSITY | I | II-III | IV | V | VI | VII | VIII | IX | X+
SHAKING | Not felt | Weak | Light | Moderate | Strong | Very strong | Severe | Violent | Extreme
DAMAGE | none | none | none | Very light | Light | Moderate | Moderate/Heavy | Heavy | V. Heavy



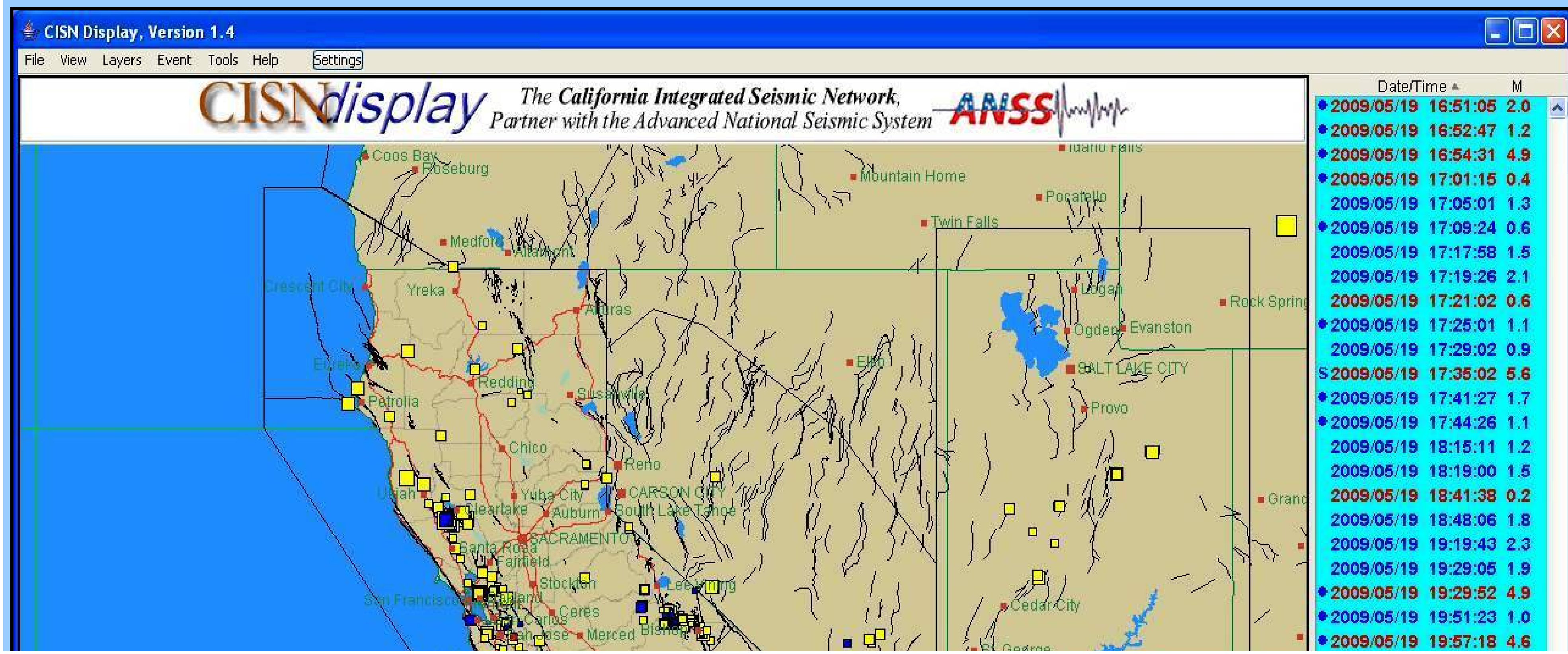
This map generated by USGS is a example of different types of data shown by shakeMap.

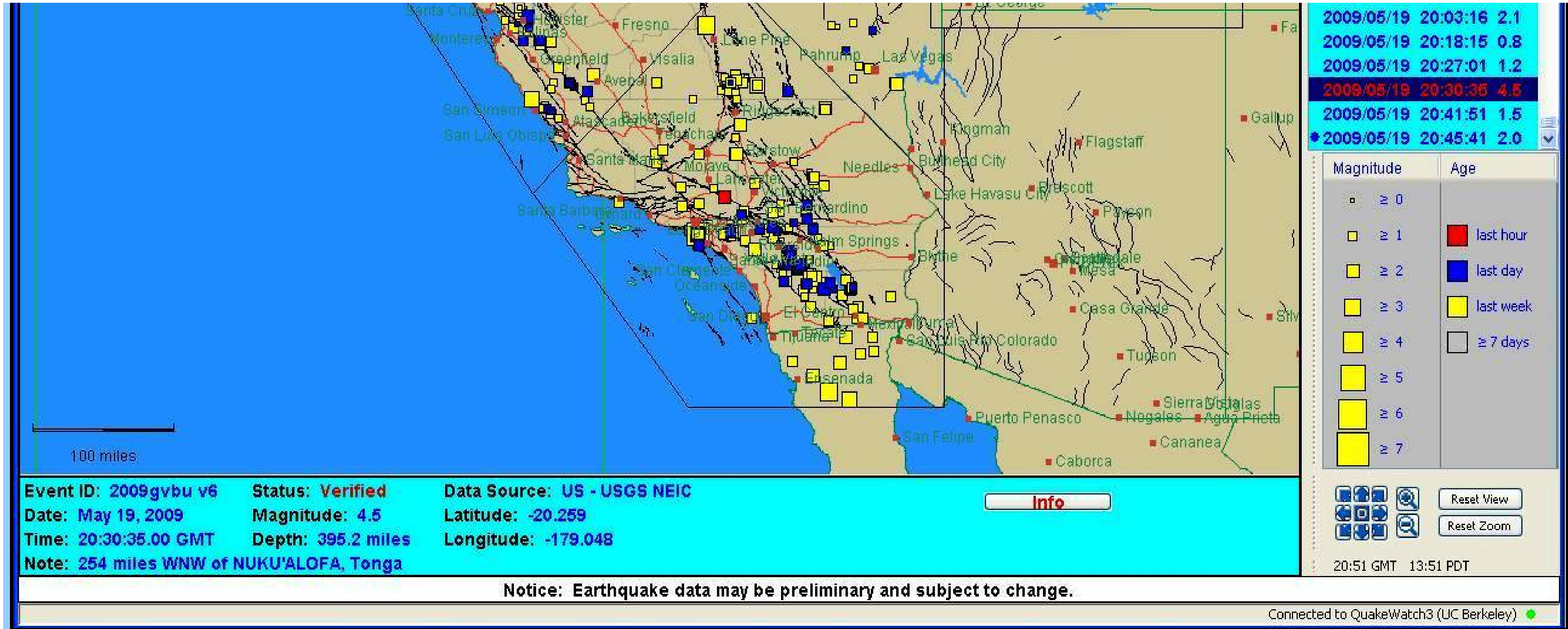
([**M4.7 – Greater Los Angeles Area, California**]**)**





The [SCSN](#) seismic monitoring stations . ([Clickable Station Map](#))





The [CISN display] which is a real- time earthquake notification system.

Analysis :

***T*he main reason for a development of an seismic network is due to the importance of understanding earthquakes by combining the analysis of regions were earthquakes are prone to occur . This in turn will create a much more robust understanding of future quakes and there predictions and allow state agencies , especially disaster response teams, vidal information of location, severity of damage , and magnitude of the quake . This will insure that the right personal respond to specific locations were damage from an earthquake has occurred . Also, it will allow the emergency responders to know ahead of time that the region where a quake has occurred may be subjected to more after shocks which in turn will cause more damage due to the intensity of the shaking of the region which was analyzed by seismologists in the past by creating earthquake scenarios by the use of shakemaps which can inform seismologist of specific locations where a earthquake can cause the most damage. The probabilities of a major quake occurring in the bay area region shows to why a seismic network is needed . The Southern California region is also prone to intense earthquake activity . The [map] above shows that the majority of the population in Southern California**

are at extreme risk . Therefore, the Southern California Seismic Network (SCSN) monitors the earthquake activity within the region and is active in providing real time seismic data to other state agencies such as the DWR earthquake engineering, which one of its primary responsibility is the transport of fresh water which is pumped from the Northern California and send by aqueducts down to Southern California to provide drinking water for the millions of people who live in the most populist region in California. The SCSN has 350 seismic stations in the Southern California region . Most of the data is transmitted via internet , microwave transmissions, radio signals, and phone lines which are private to cuts down on interruption which are prone in commercial phone lines. This is just one example of the several agencies in California that incorporate there own seismic net into CISN , so the data can be shared by other agencies.

Conclusion:

The seismic network has been developed to operate as a real- time seismic warning and monitoring system which allows state agencies and independent agencies such as Cal tech, CGS, USGS, U.C. Berkeley, and USC to be combined together as an intricate network system . This allows all agencies able to communicate with each other and share vital seismic data, which each agency weather private or government can use for their own needs. The State of California is due for a major earthquake and it has the most active earthquake faults than any other state in the U.S. (not including Alaska). This is the main reason why a expansion of the seismic network is necessary and must be properly funded and allow to grow. There are still many hidden earthquake faults in California which can rupture and cause considerable damage and loss of life at any given time. The expansion of the seismic network will allow more seismic stations to be placed where hidden earthquake faults are located. This must be done in order to fully understand the complex web of thousands of earthquake faults that cover the entire California region.

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