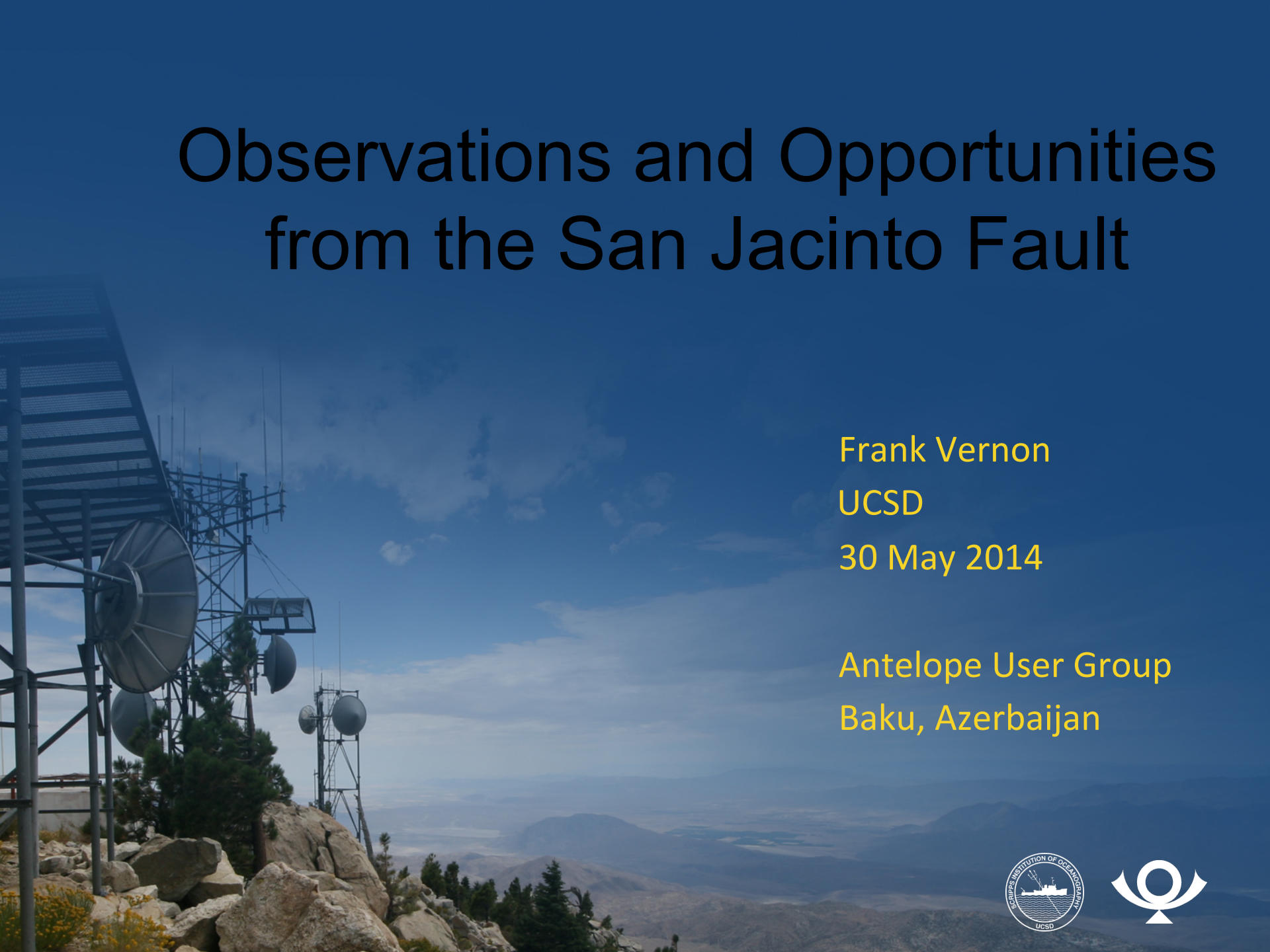
Observations and Opportunities from the San Jacinto Fault



Frank Vernon
UCSD
30 May 2014

Antelope User Group
Baku, Azerbaijan

Acknowledgements

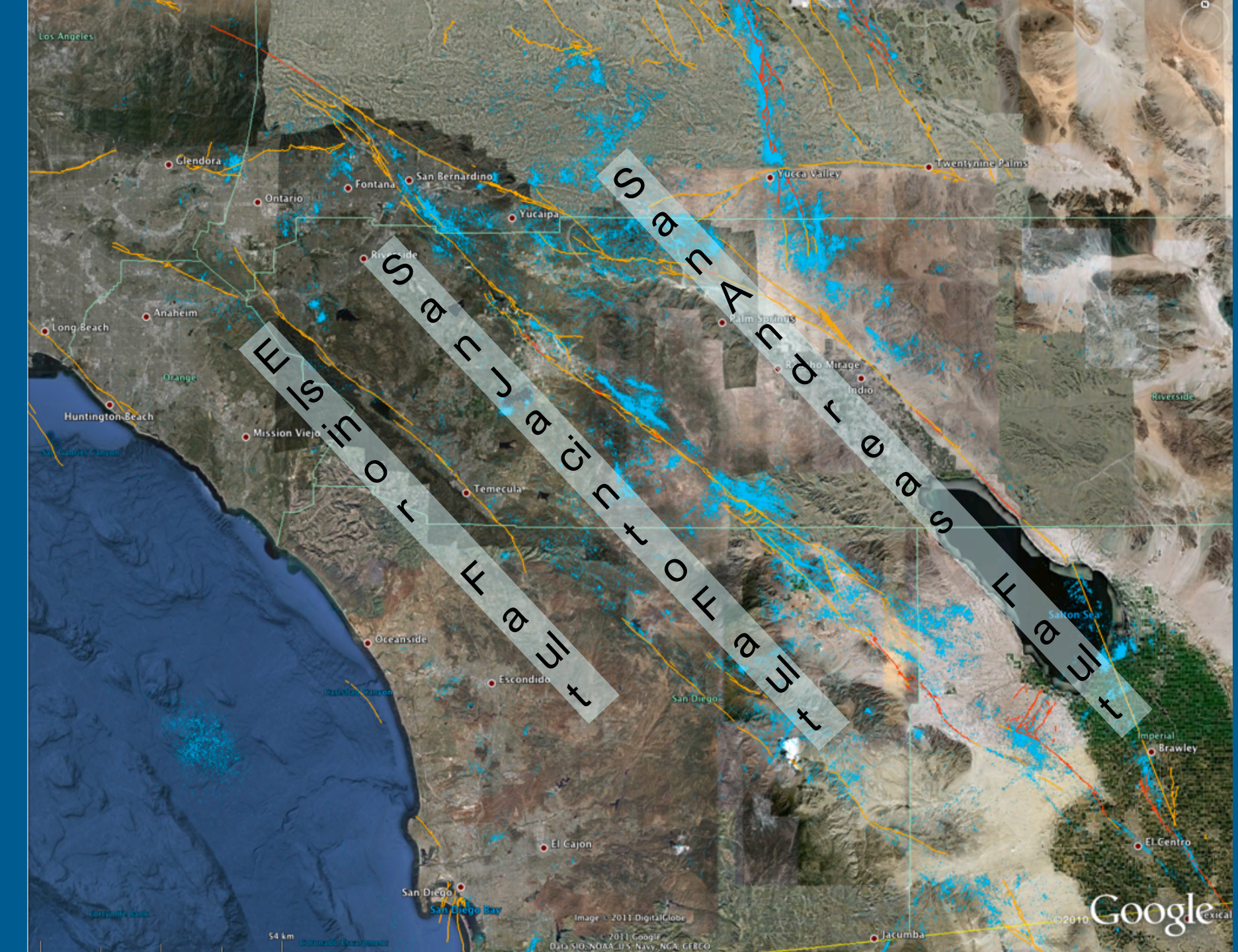
Anza-Borrego Desert State Park

San Jacinto Ranger District,
San Bernardino National Forest

Many local private landowners

National Science Foundation

SJFZ Project Team


Los Angeles
Glendora
Fontana
San Bernardino
Ontario
Yucaipa
Yucca Valley
Twentynine Palms
Riverside
Anaheim
Long Beach
Palm Springs
Indio
Orange
Huntington Beach
Mission Viejo
Temecula
Oceanside
Escondido
San Diego
El Cajon
San Diego Bay
Salton Sea
Imperial
Brawley
El Centro
Jacumba
San Andreas Fault
San Jacinto Fault
Elsinore Fault
Image © 2011 DigitalGlobe
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Data SIO, NOAA, U.S. Navy, NGA, GEBCO
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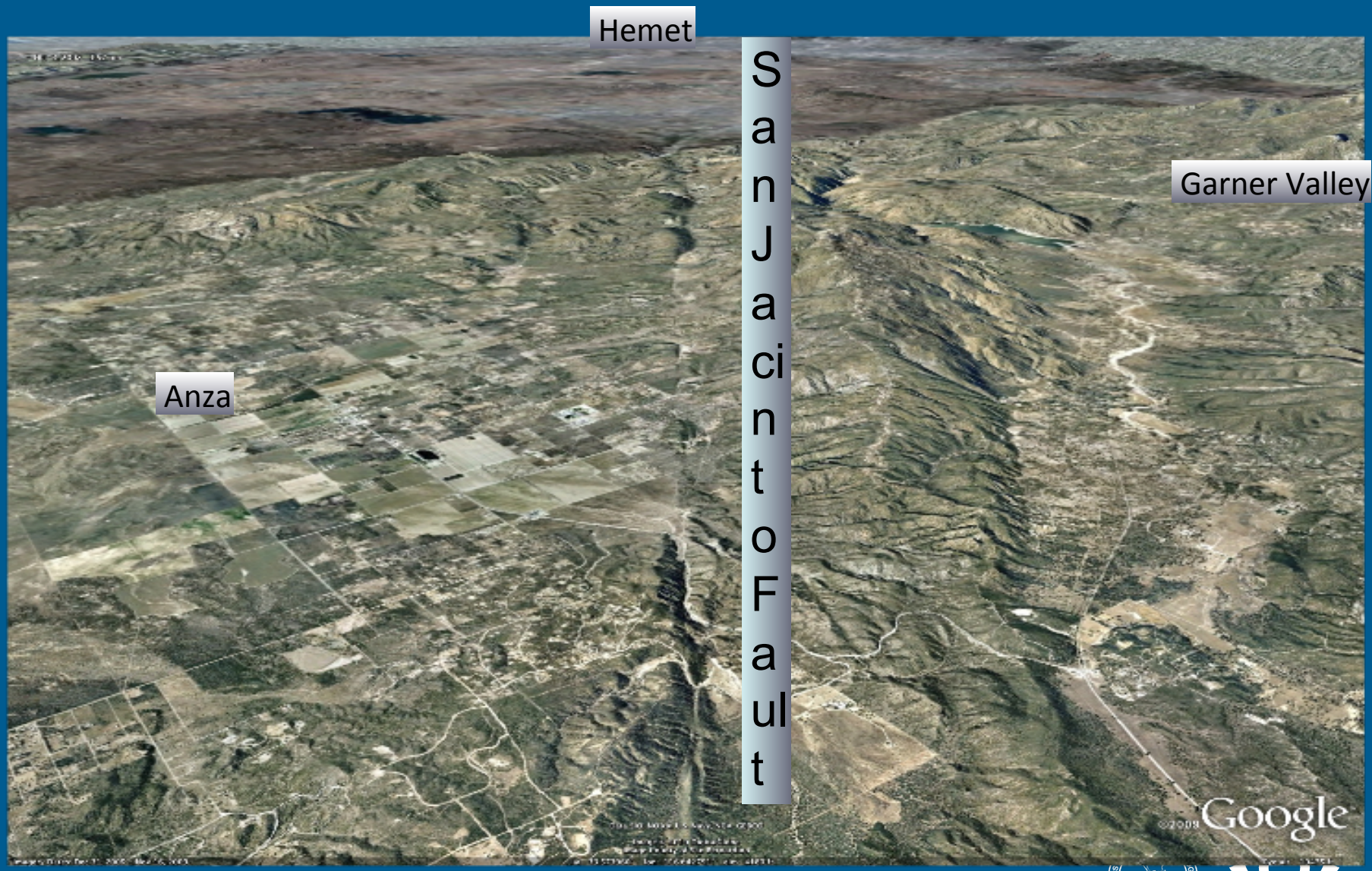
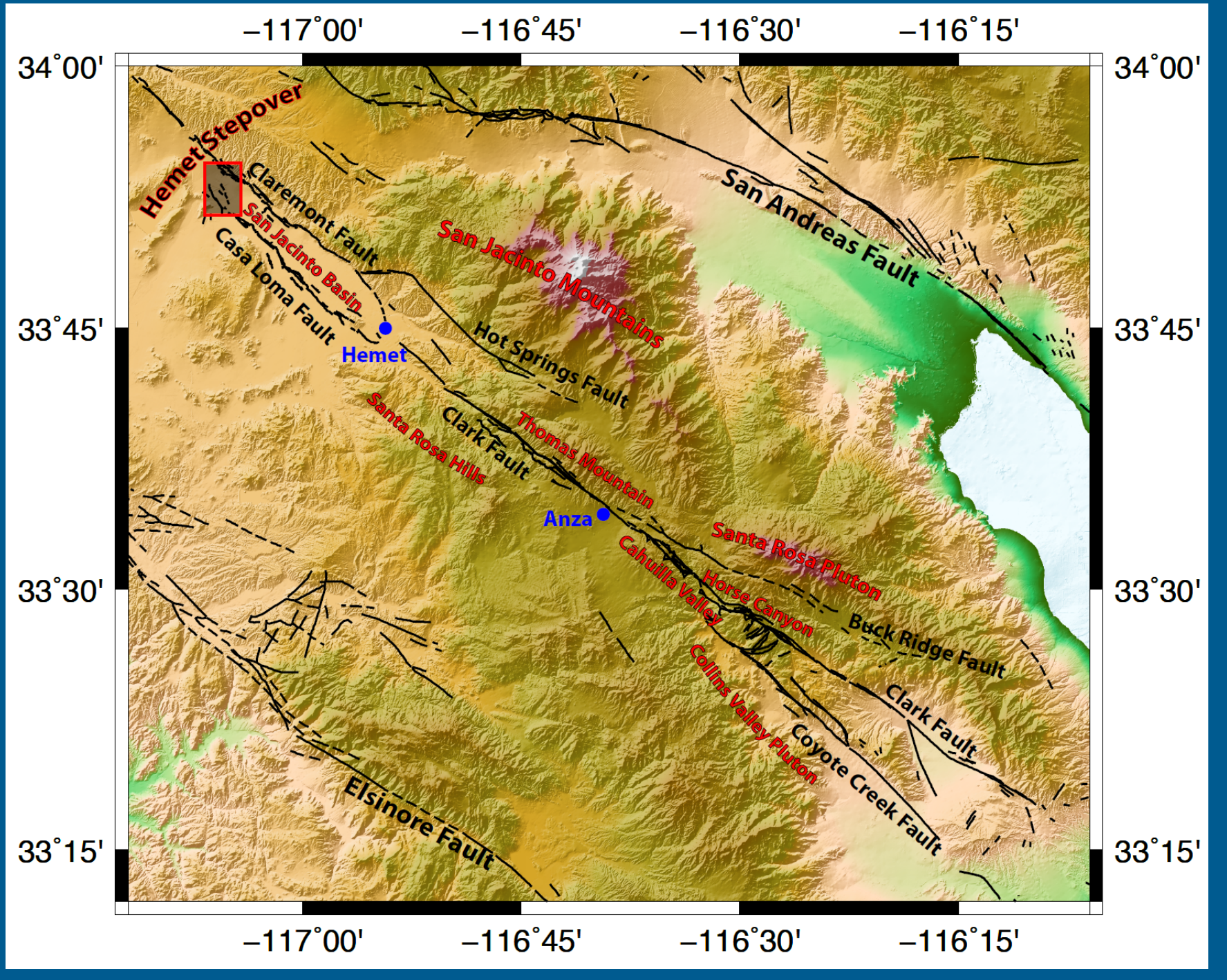
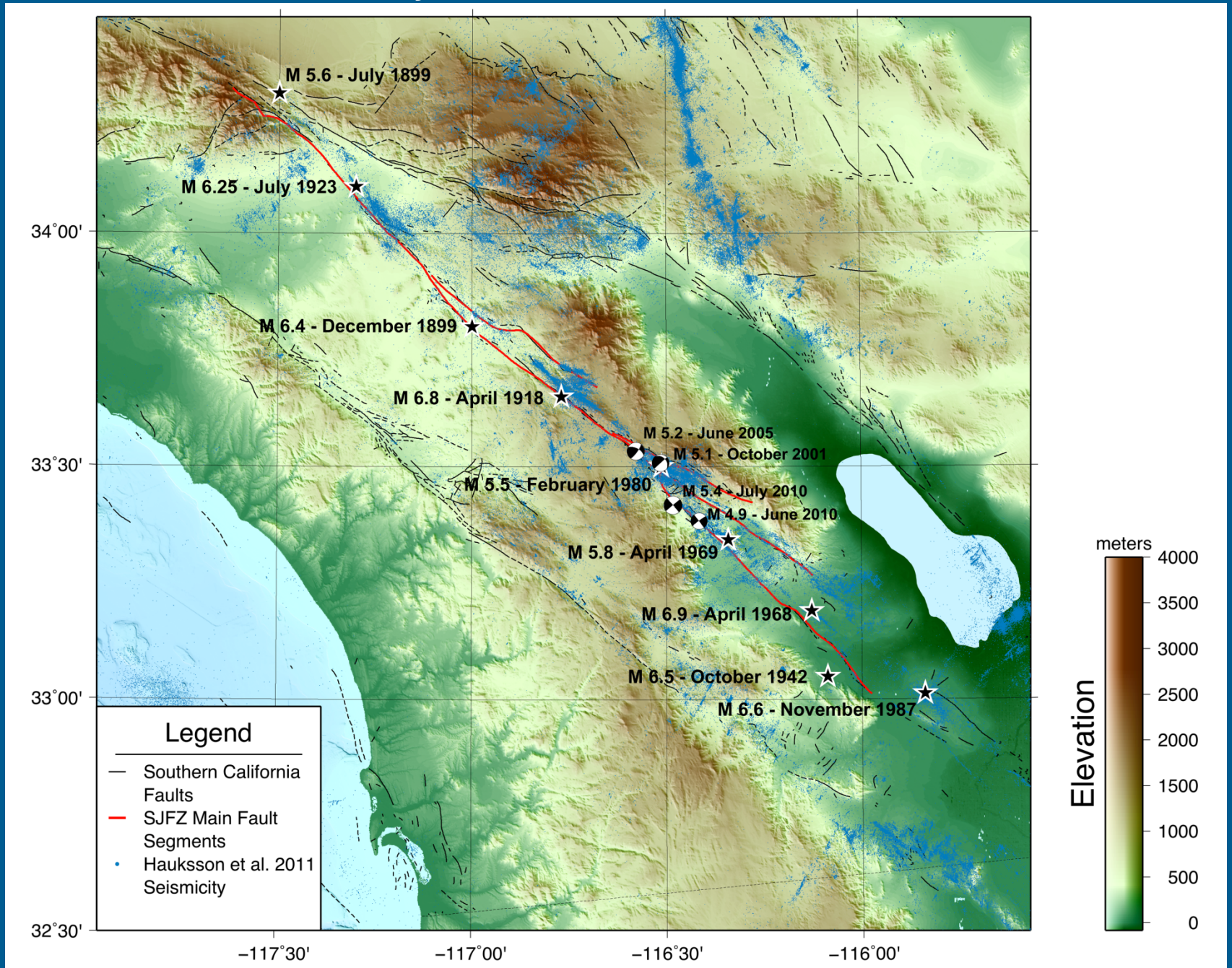
54 km

San Jacinto Fault Zone




−117°00'
−116°45'
−116°30'
−116°15'
34°00'
33°45'
33°30'
33°15'
Hemet Stepover
Claremont Fault
San Jacinto Basin
Casa Loma Fault
San Jacinto Mountains
San Andreas Fault
Hemet
Hot Springs Fault
Santa Rosa Hills
Clark Fault
Thomas Mountain
Anza
Santa Rosa Pluton
Cahuilla Valley
Horse Canyon
Buck Ridge Fault
Collins Valley Pluton
Clark Fault
Coyote Creek Fault
Elsinore Fault

San Jacinto Fault Zone



Recent San Jacinto Fault Ruptures

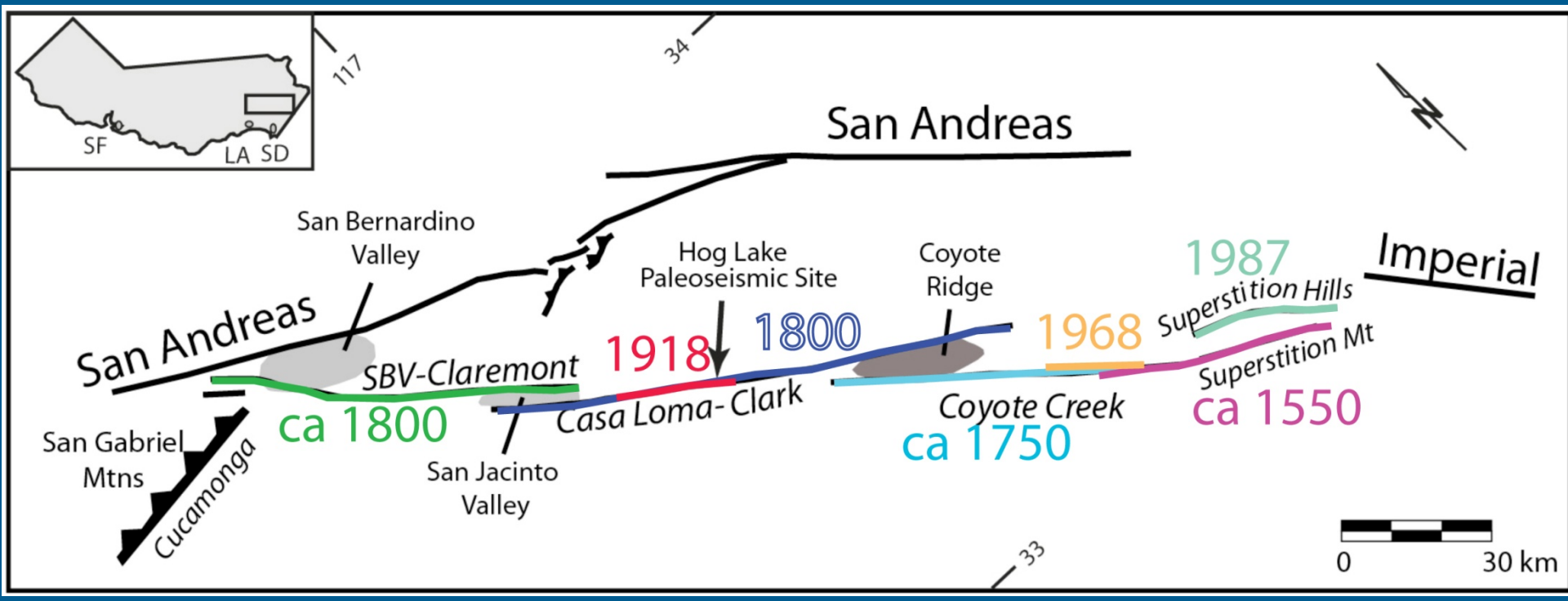
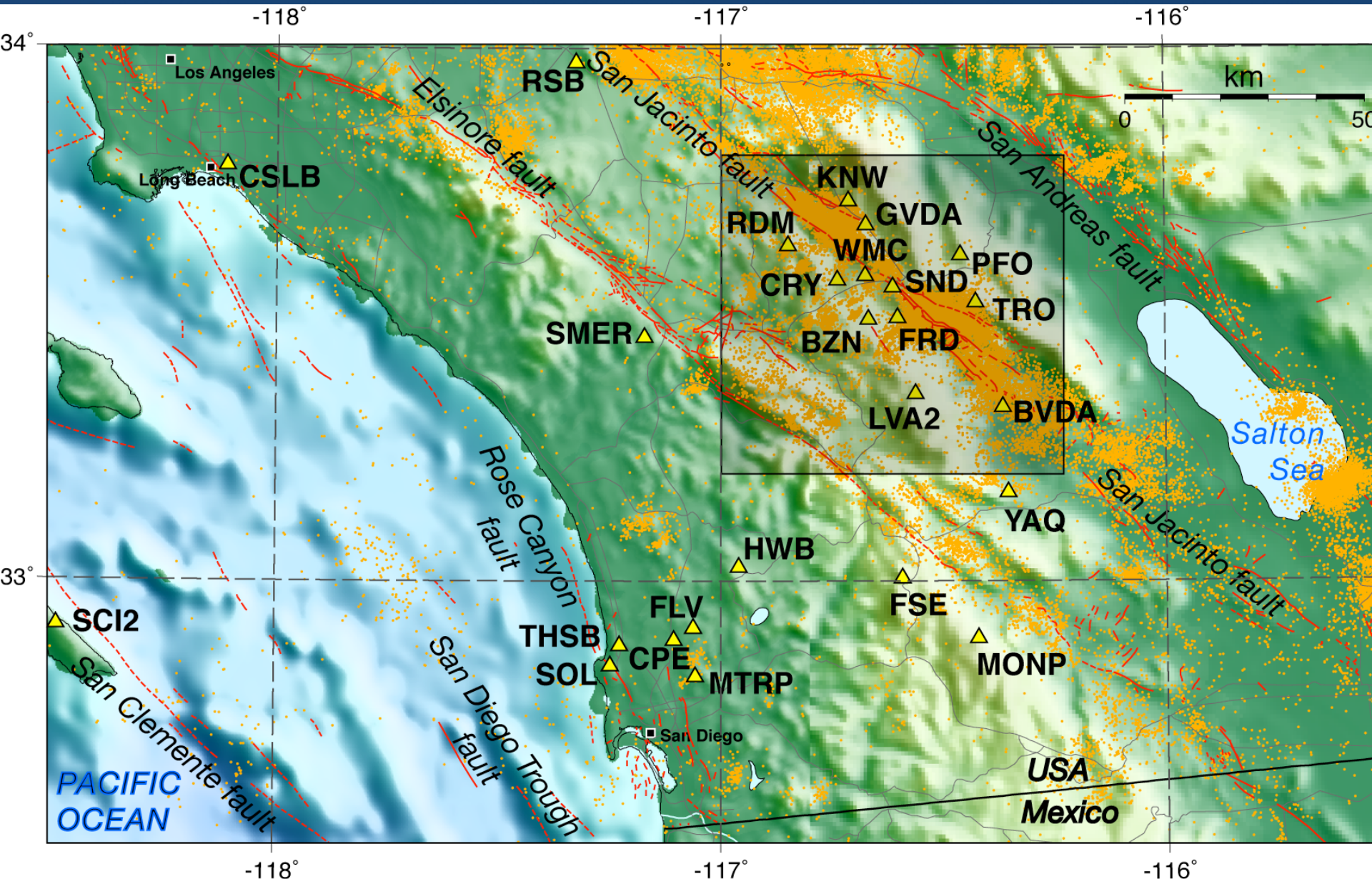
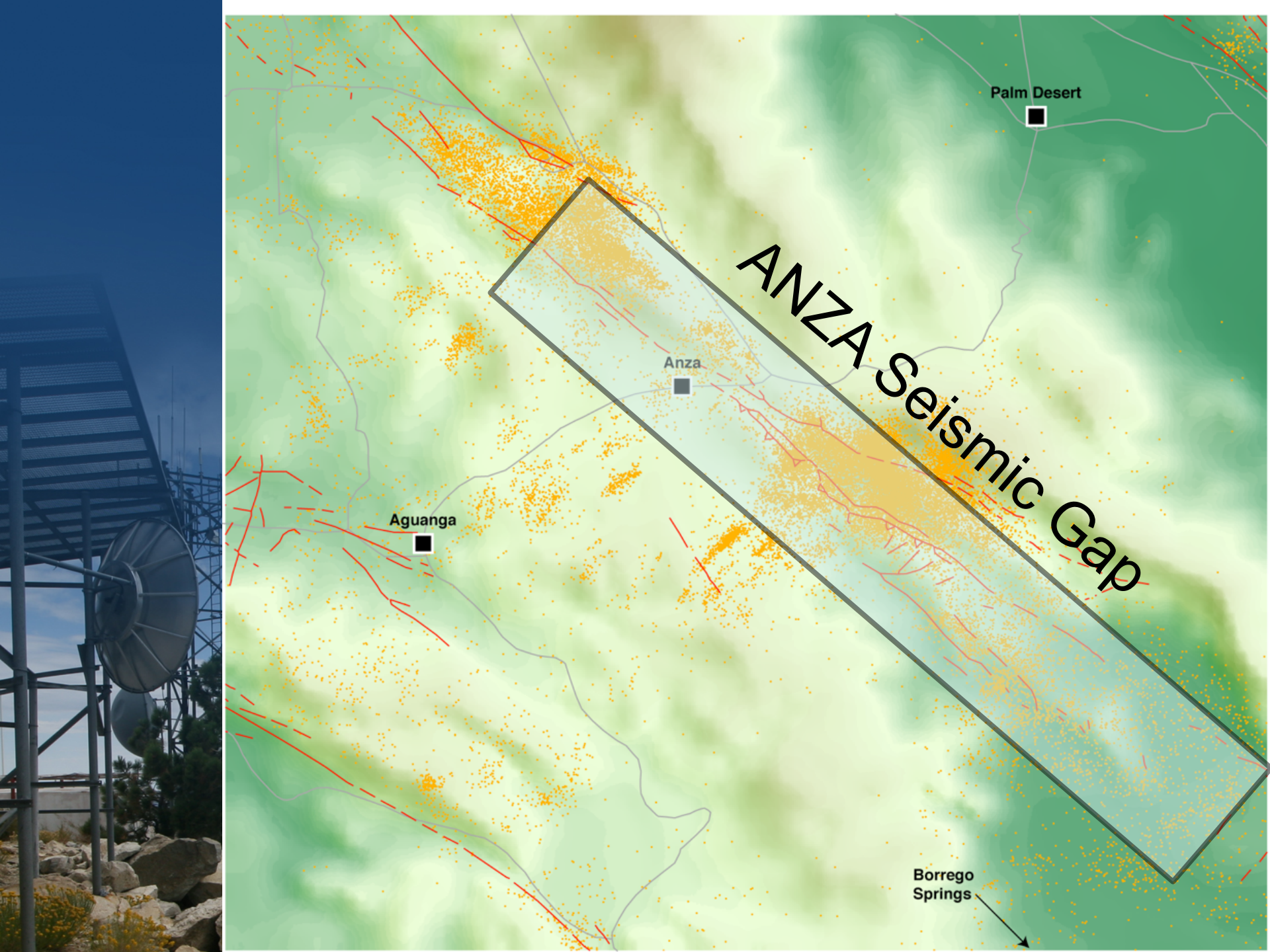
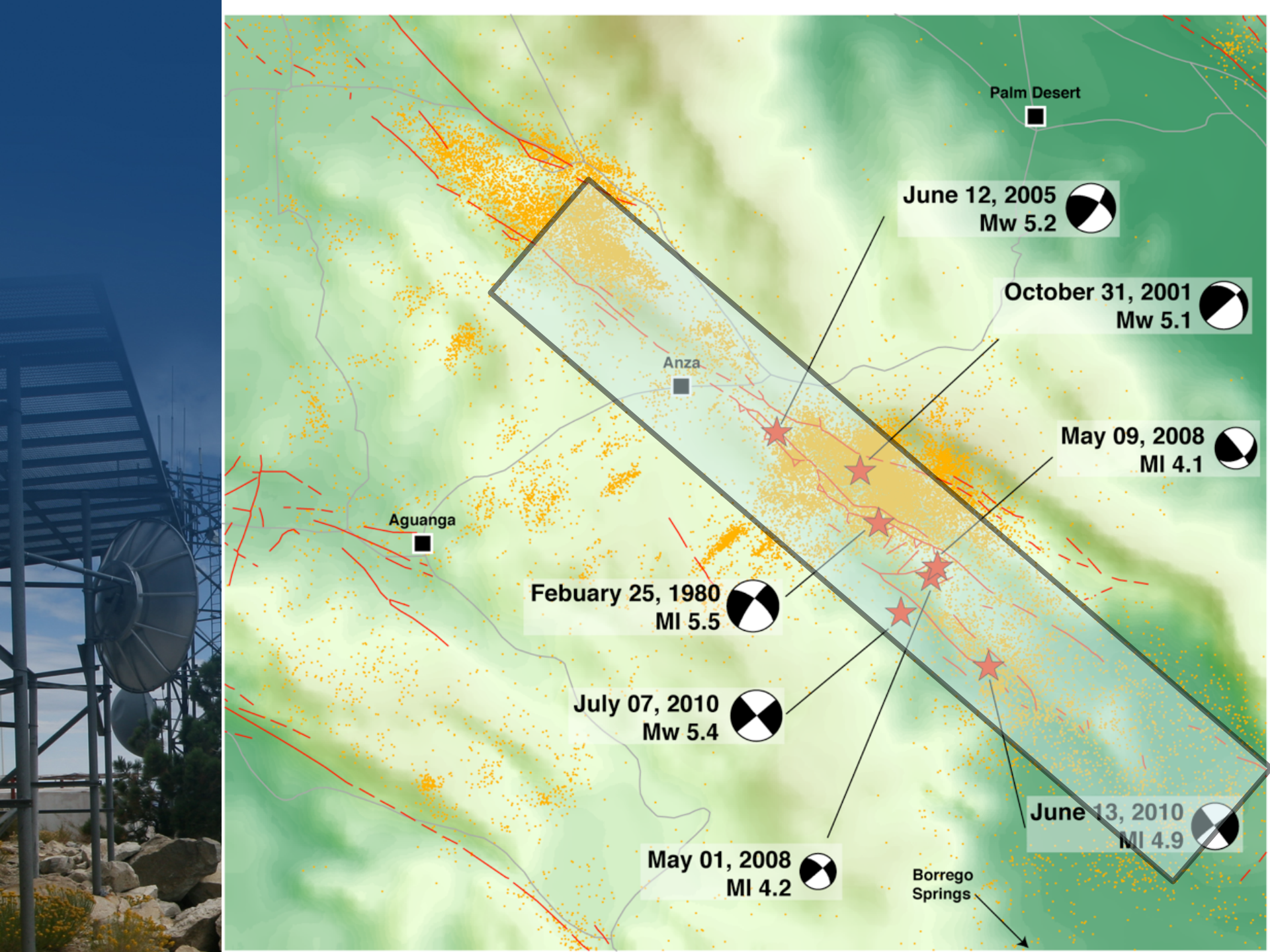


Figure provided by Tom Rockwell

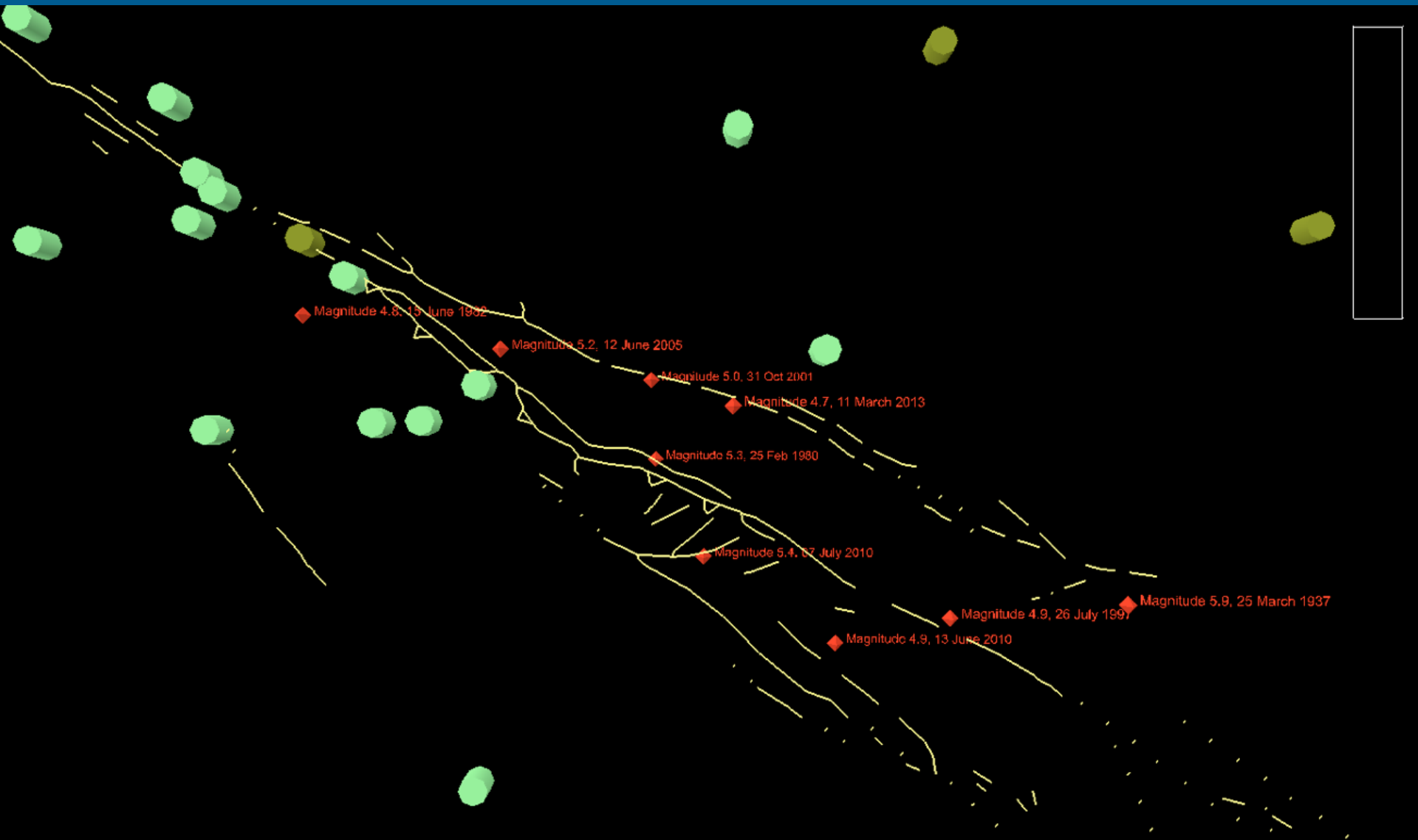
ANZA Network 1982-Present



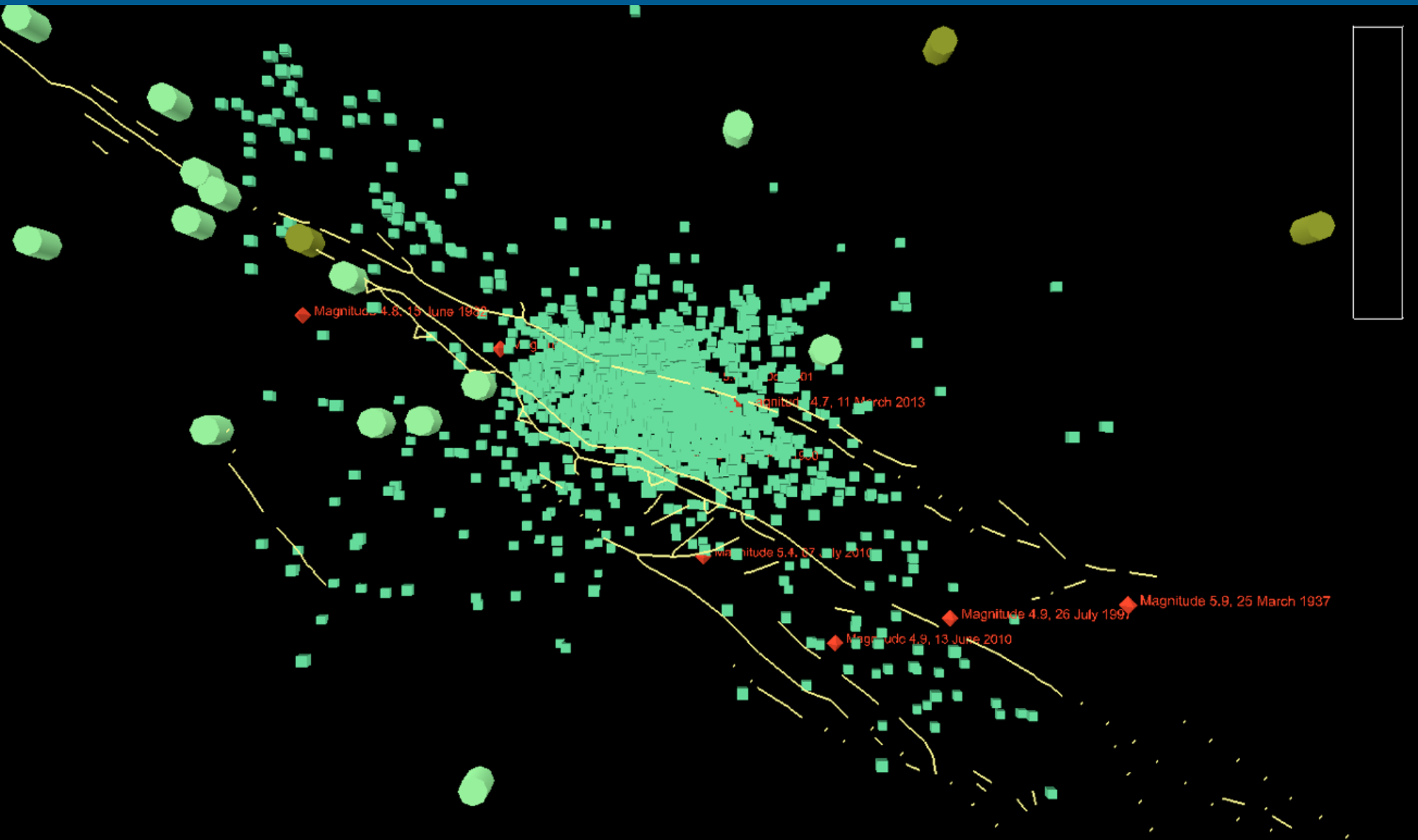

Palm Desert
ANZA Seismic Gap
Anza
Aguanga
Borrego
Springs


Palm Desert
June 12, 2005
Mw 5.2
October 31, 2001
Mw 5.1
Anza
May 09, 2008
Ml 4.1
Aguanga
Febuary 25, 1980
Ml 5.5
July 07, 2010
Mw 5.4
June 13, 2010
Ml 4.9
May 01, 2008
Ml 4.2
Borrego
Springs

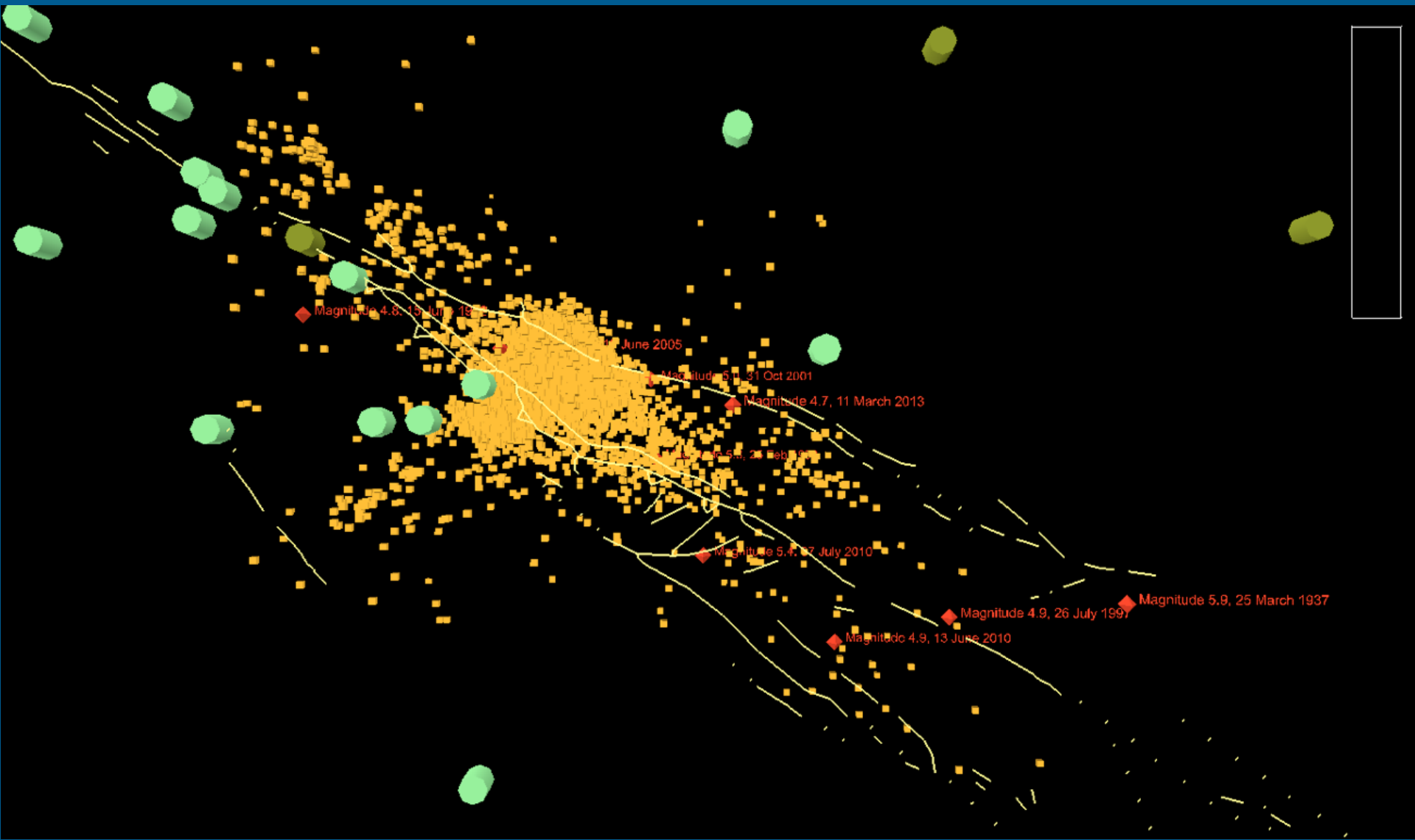
ANZA and SCSN



2001 Aftershock Sequence



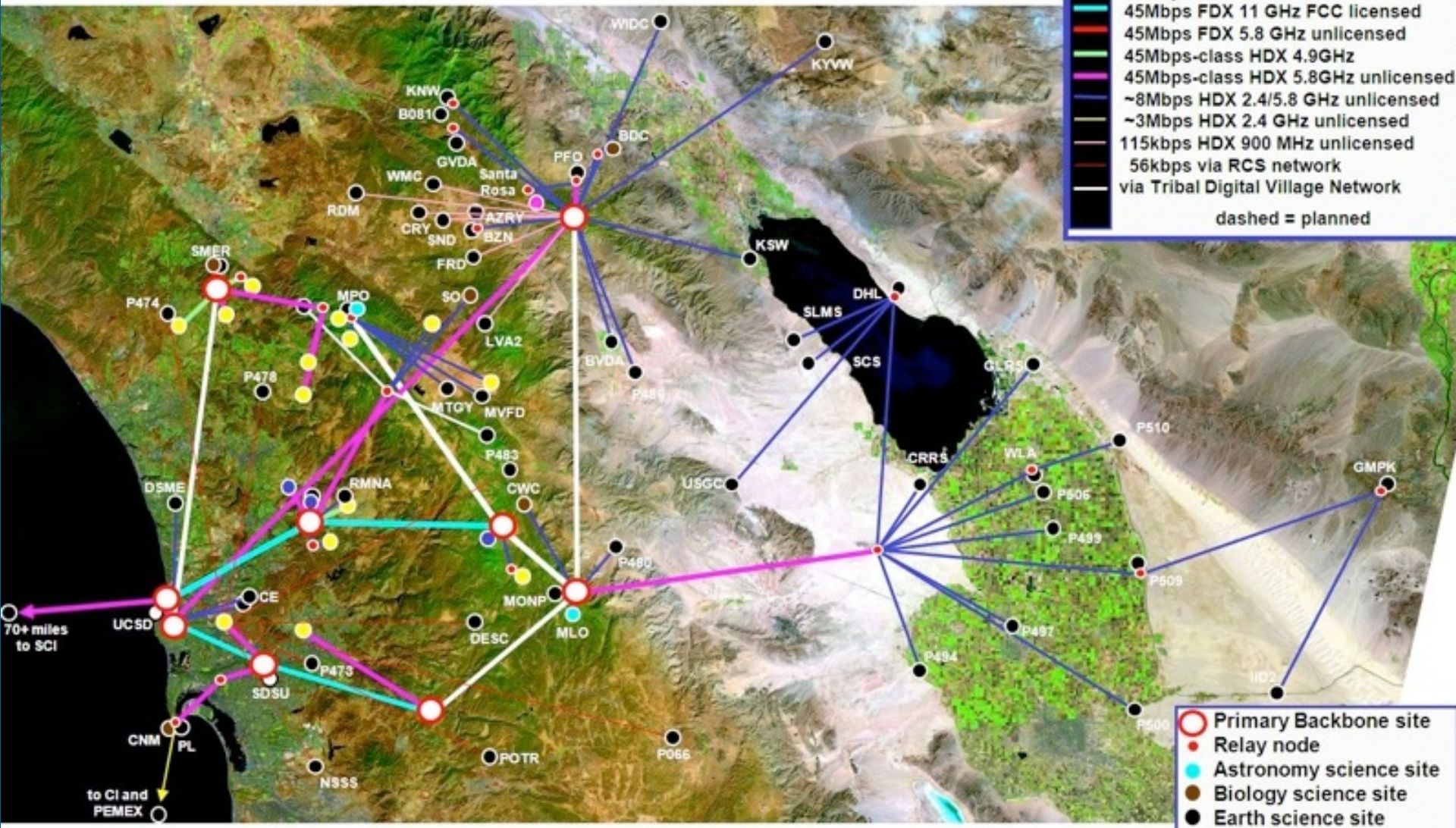
2005 Aftershock Sequence



San Jacinto Fault Zone Realtime Telemetry System

- Hardware
  - Quanterra Q330 dataloggers
  - Streckeisen STS-2, Trillium 240, Trillium 120 PH
  - Guralp CMG40T 1 Hz
  - Episensor, Shallow Borehole Episensors
- Antelope Software Package
  - Automatic detections
  - Automatic locations
  - Automatic magnitudes
  - Analyst review

HPWREN topology – January 2012

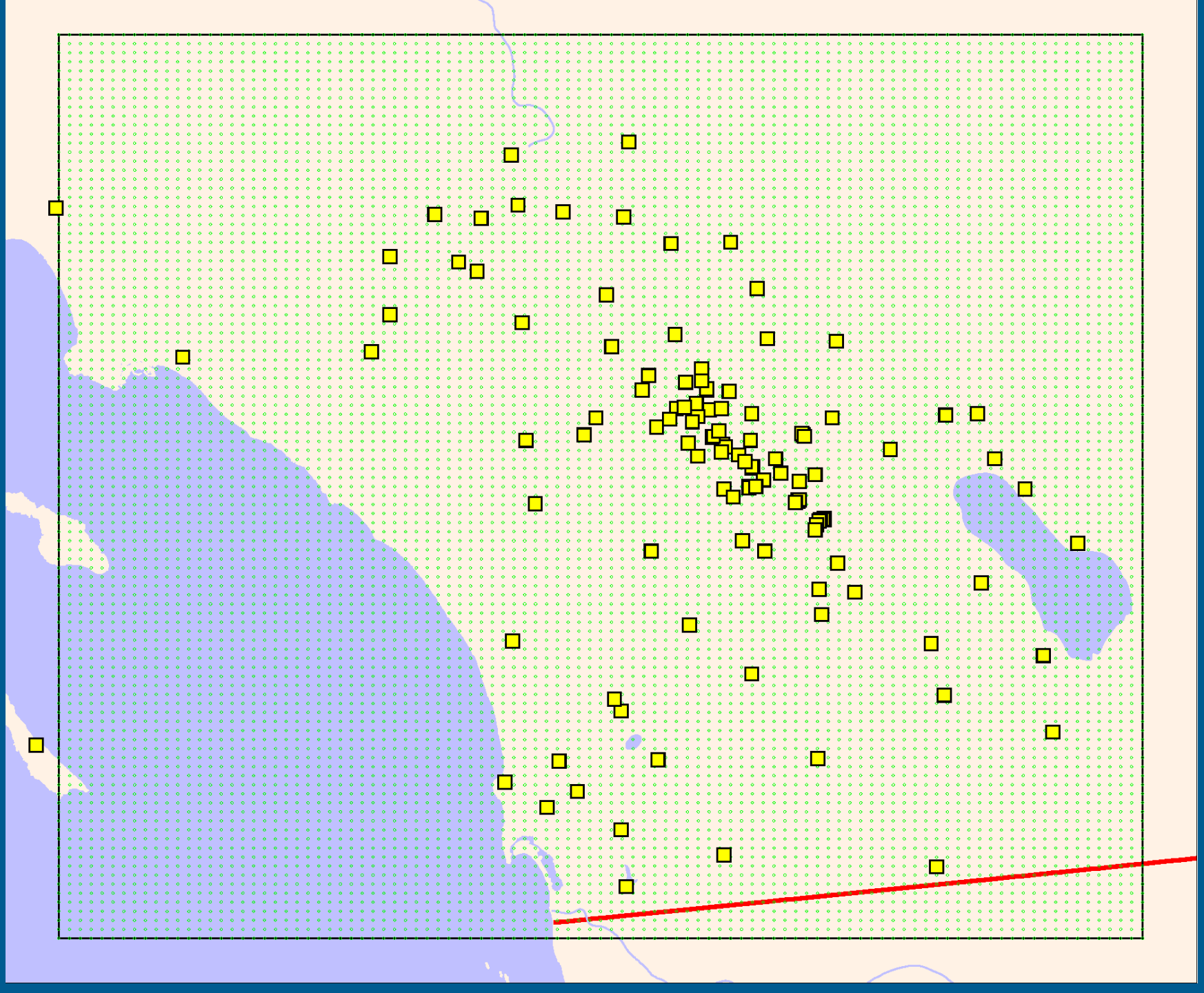


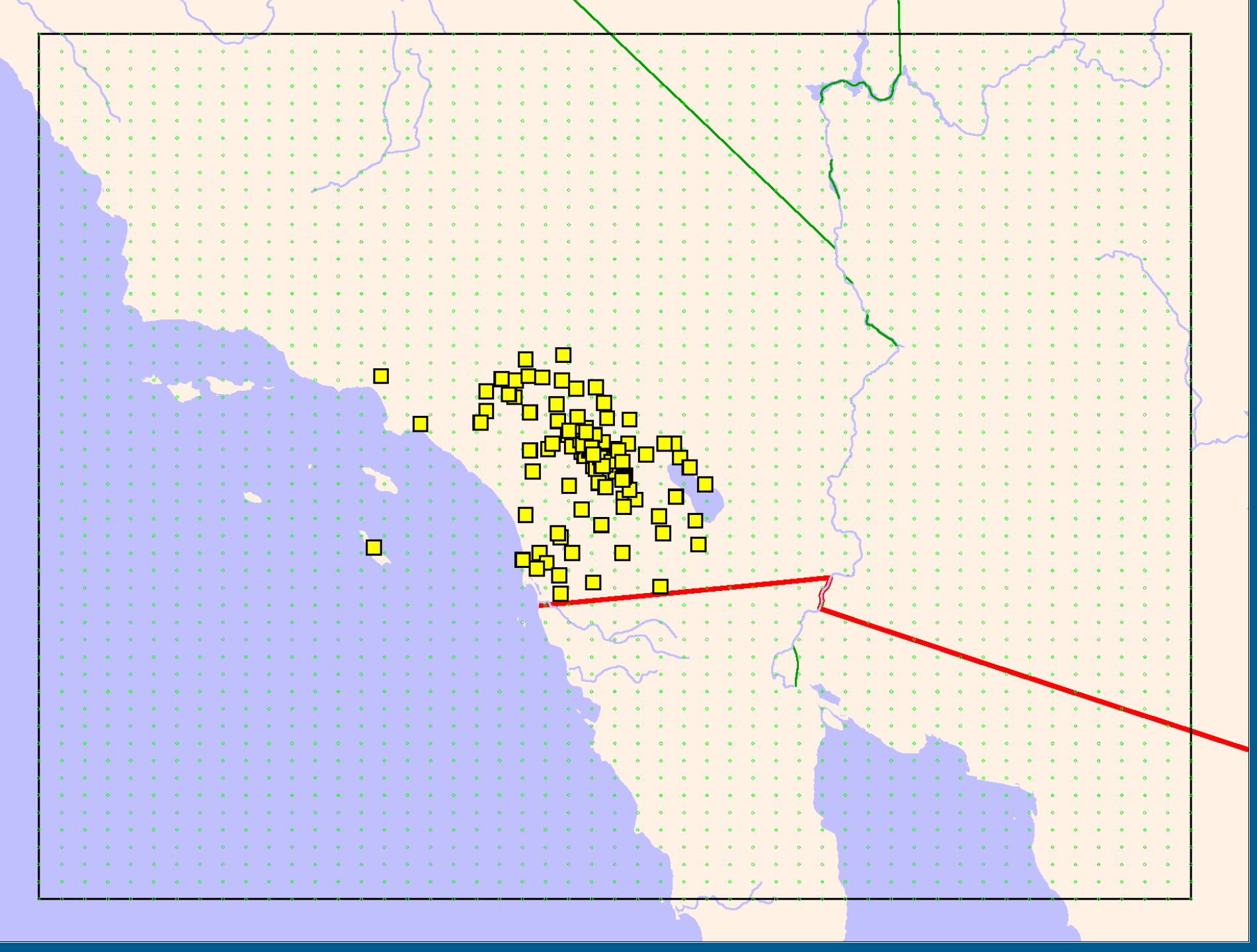
Applied Network Research

http://anr.ucsd.edu

San Jacinto Fault Zone
Realtime Virtual Observing Network

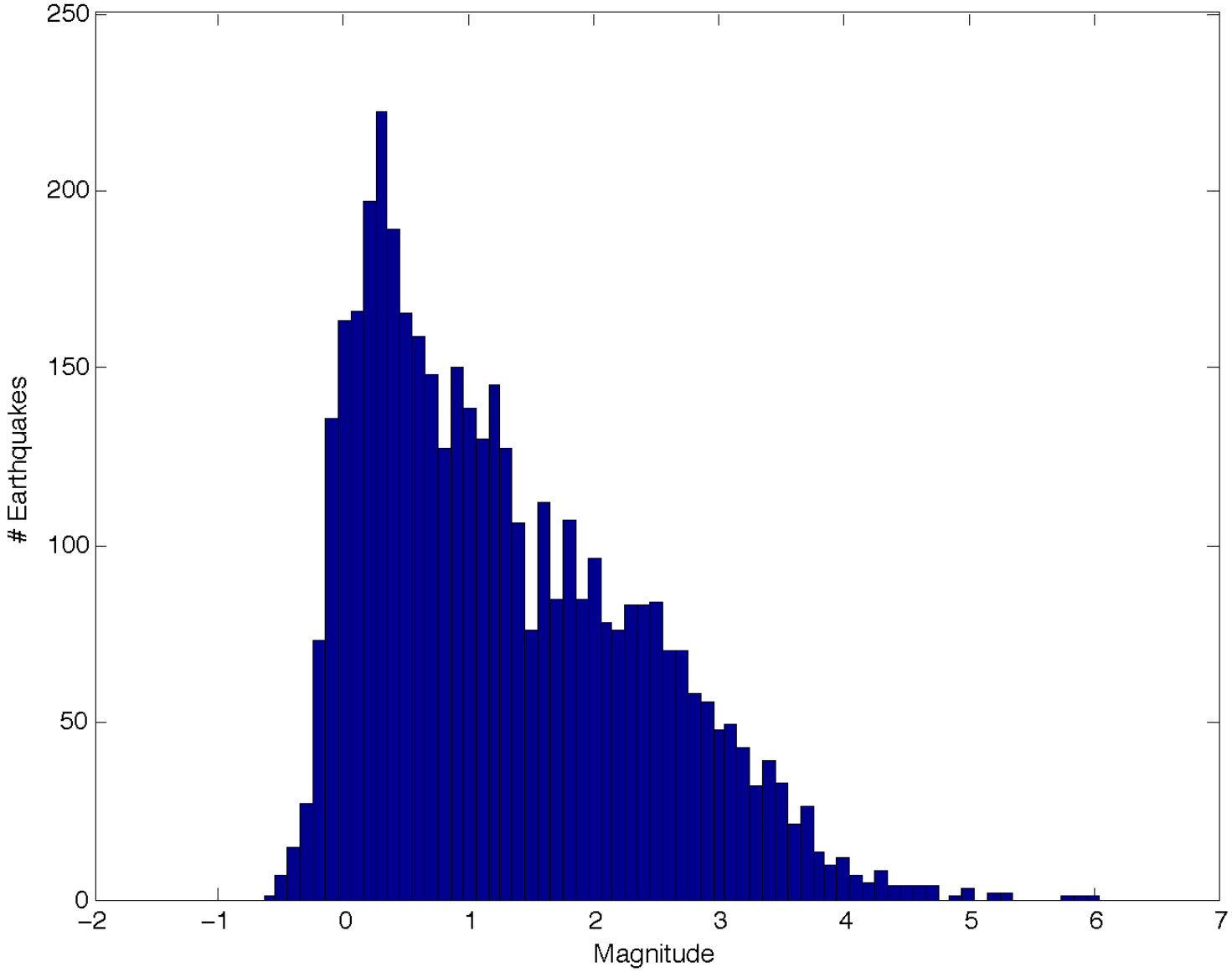
- Antelope Software for Real Time Data Integration
- Permanent Networks
  - ANZA Seismic Network (24)
  - Plate Boundary Observatory (8)
  - Southern California Seismic Network (~30)
  - UC Santa Barbara (3)
- PASSCAL
  - 5 Linear Fault Crossing Arrays
    - 45 total elements
  - 20 stand alone stations
- 8 Borehole Strainmeters
- 12 Permanent GPS

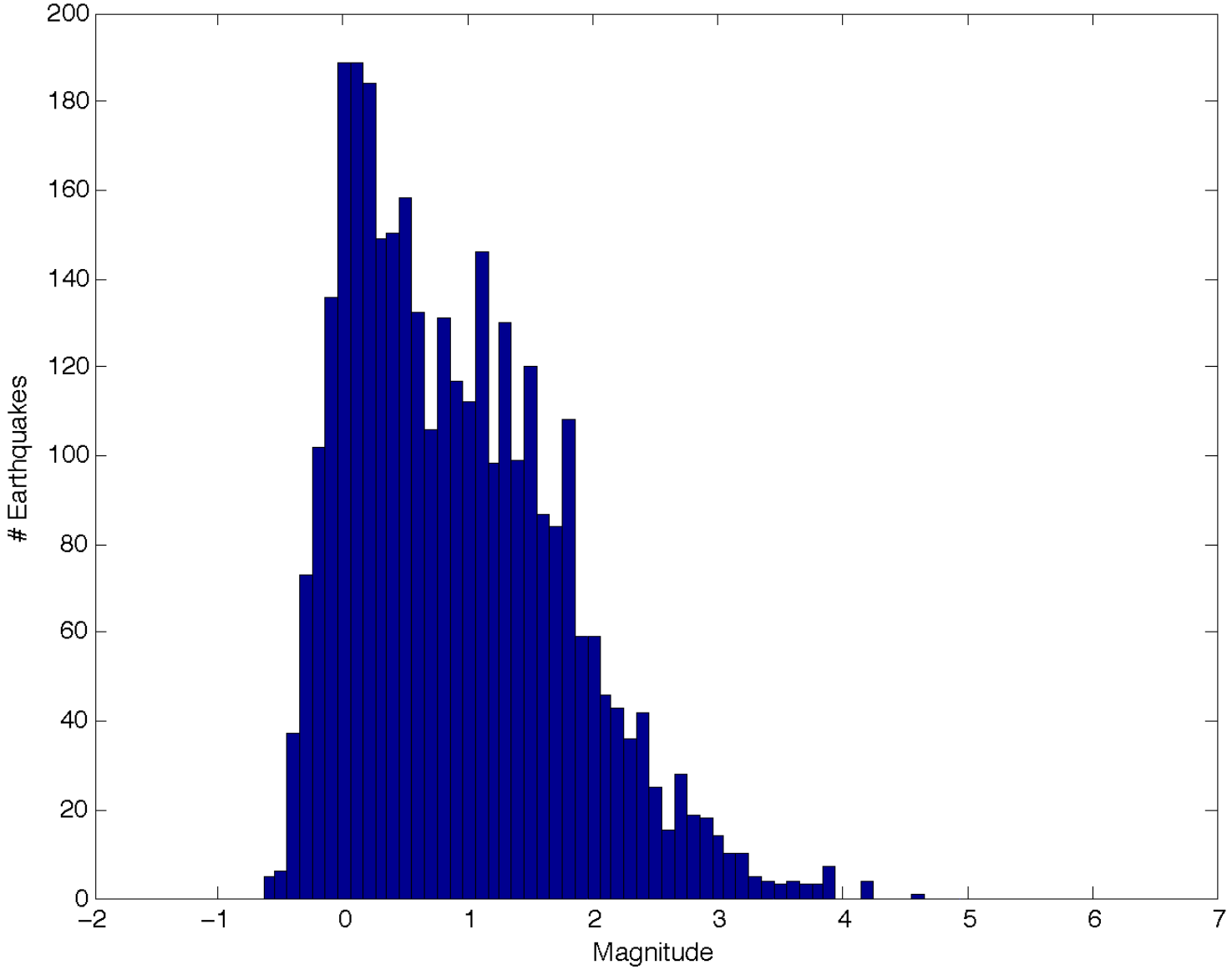


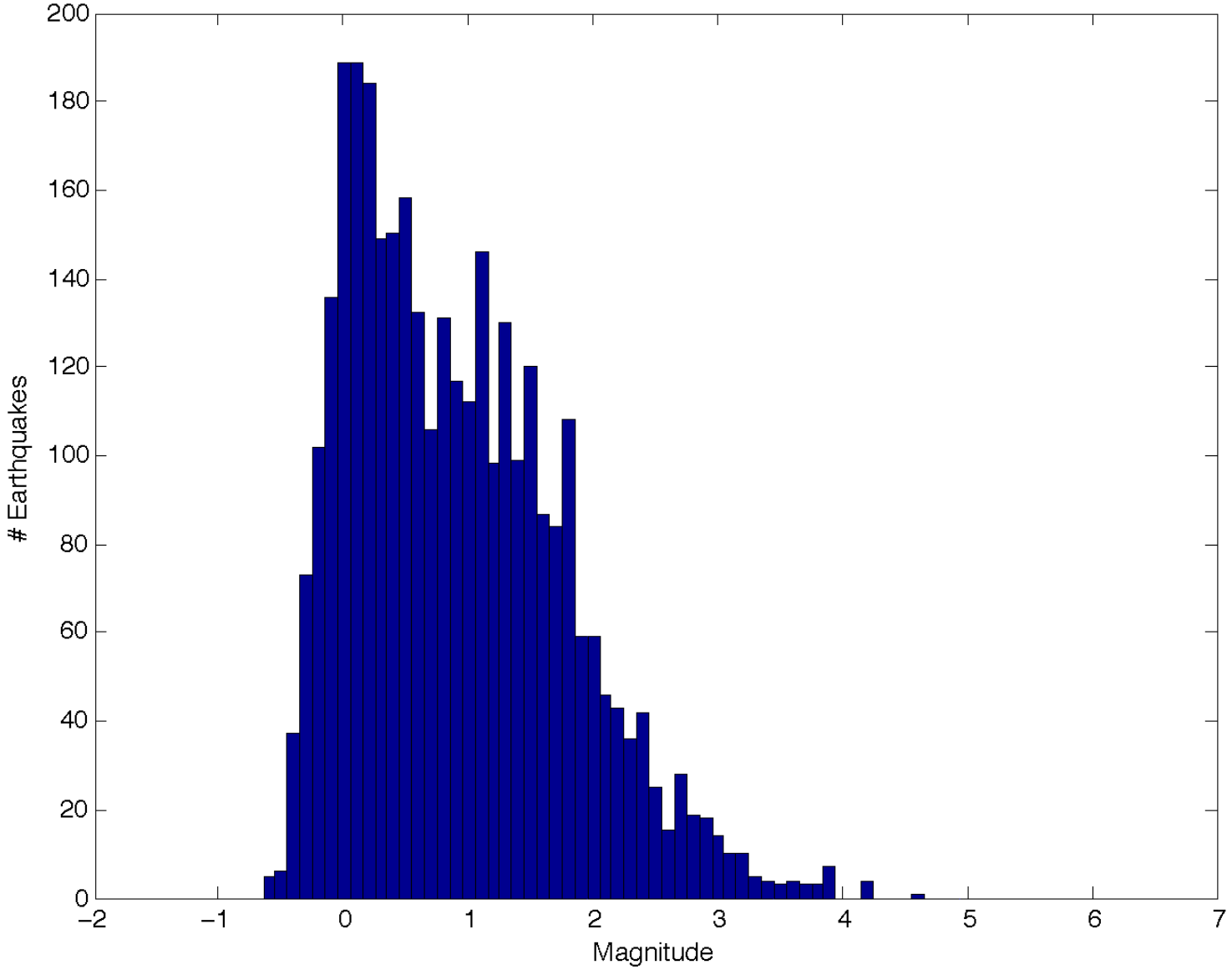


San Jacinto Fault Zone Data Management

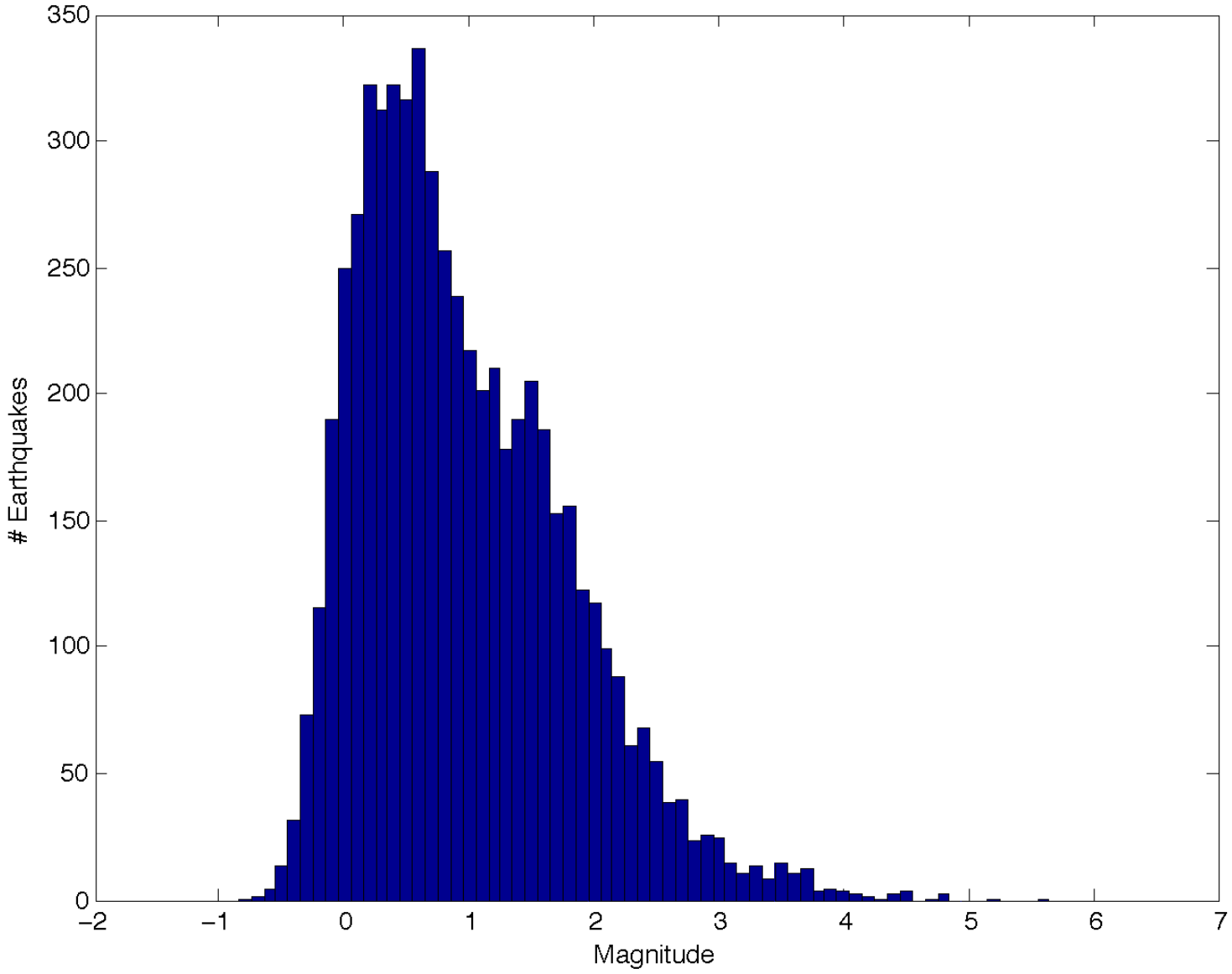
- 7-8 Gbytes/day
- 21696 events since 1 Jan 2010
- 274141 arrivals since 1 Jan 2010
- Mw 4.7 event 11 March 2013
  - 20 stations with epicentral distance < 10 km
- 5154 events since 1 Jan 2013
- 228858 arrivals since 1 Jan 2013
- all need to be reviewed by analysts
- Needs reliable automatic processing


SJFZ 2010
8908 Events
Earthquakes
Magnitude
250
200
150
100
50
0
−2
−1
0
1
2
3
4
5
6
7

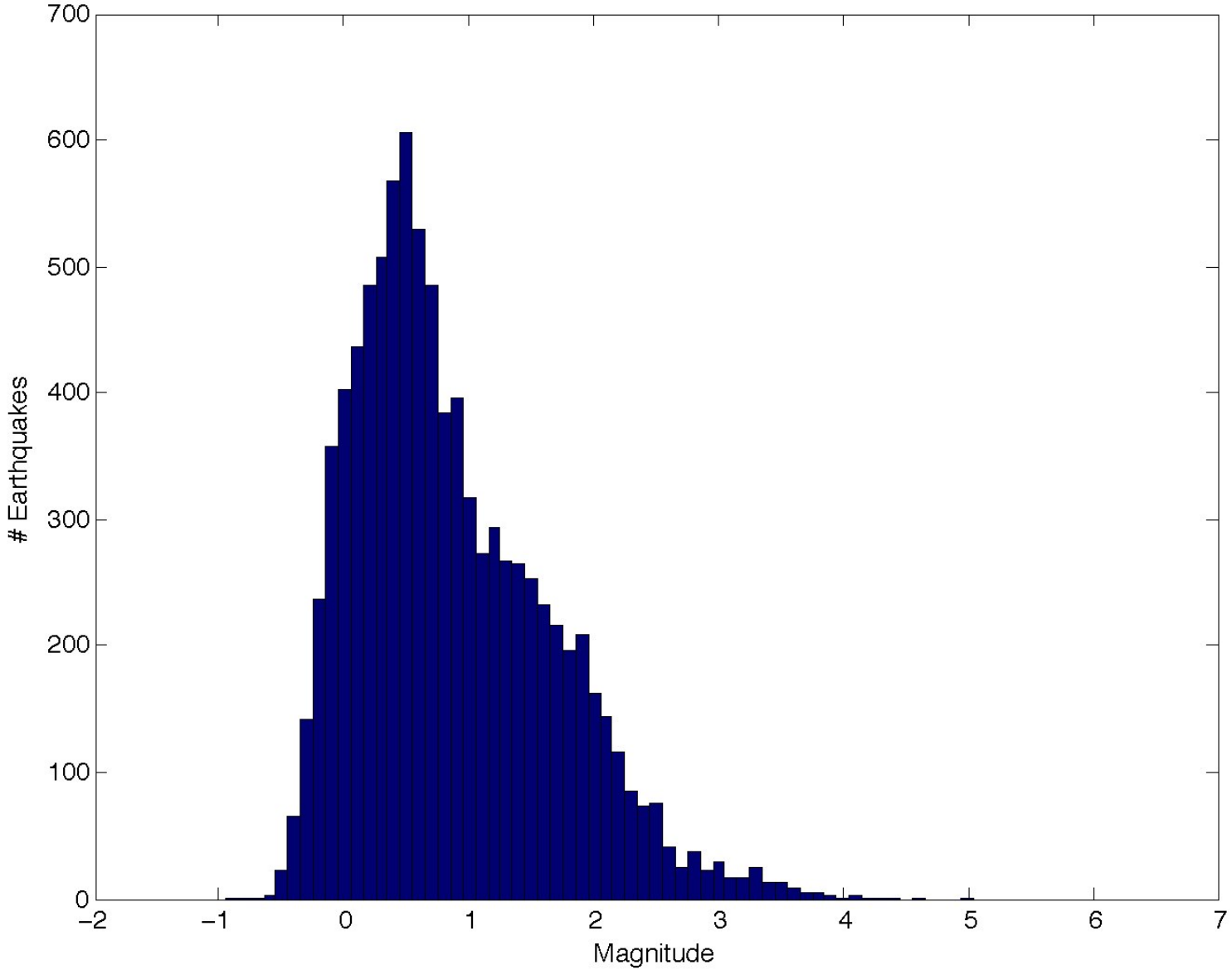

SJFZ 2011
7606 Events
Earthquakes
Magnitude
200
180
160
140
120
100
80
60
40
20
0
−2
−1
0
1
2
3
4
5
6
7


SJFZ 2011
7606 Events
Earthquakes
Magnitude
200
180
160
140
120
100
80
60
40
20
0
−2
−1
0
1
2
3
4
5
6
7

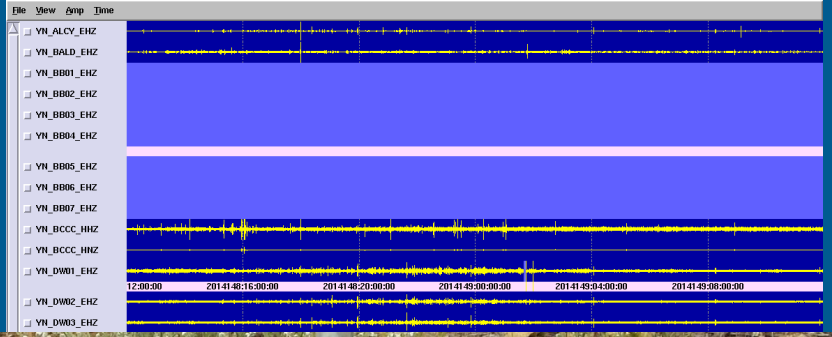
SJFZ 2012
7863 Events



SJFZ 2013
11338 Events

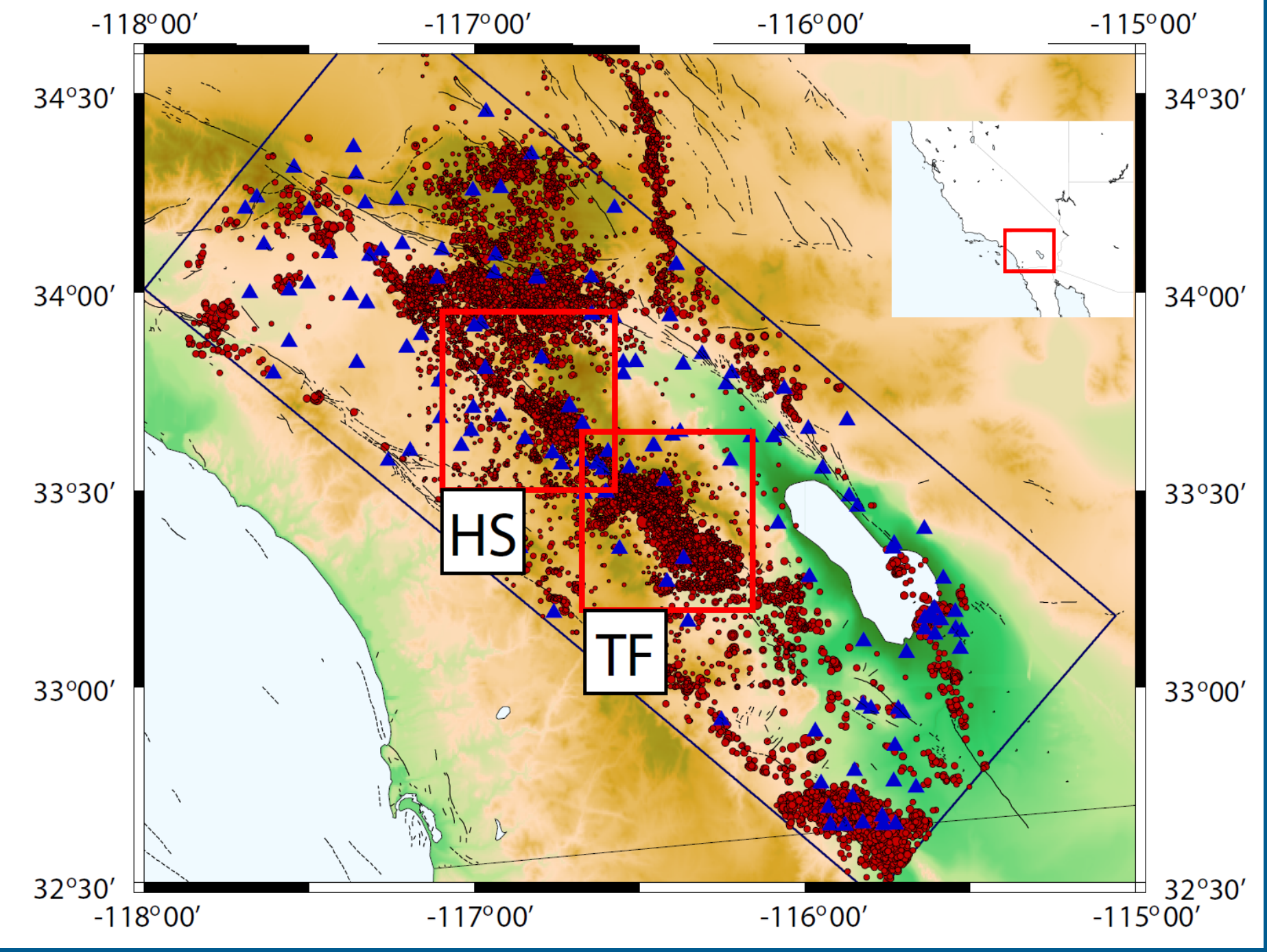


Current data

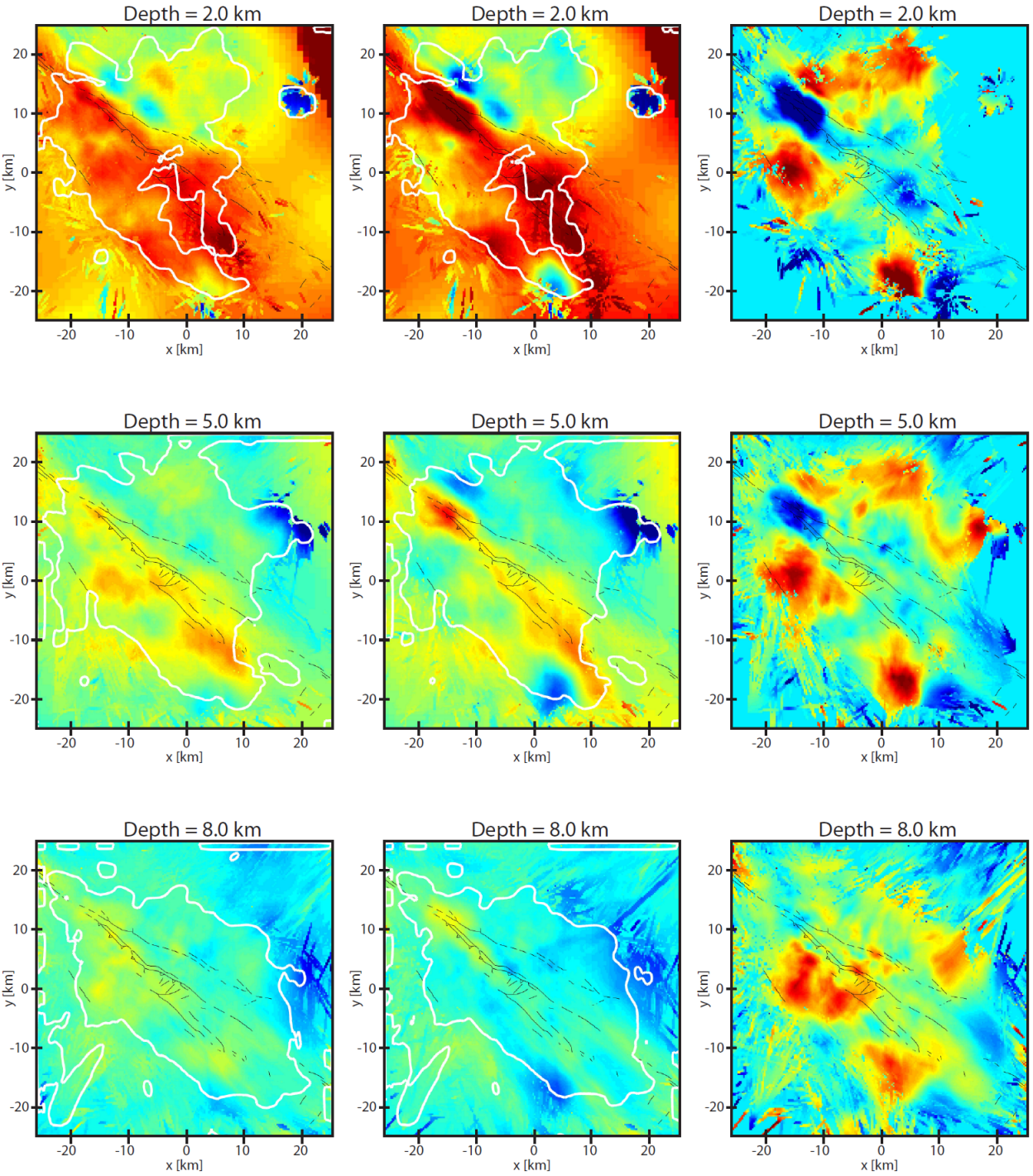


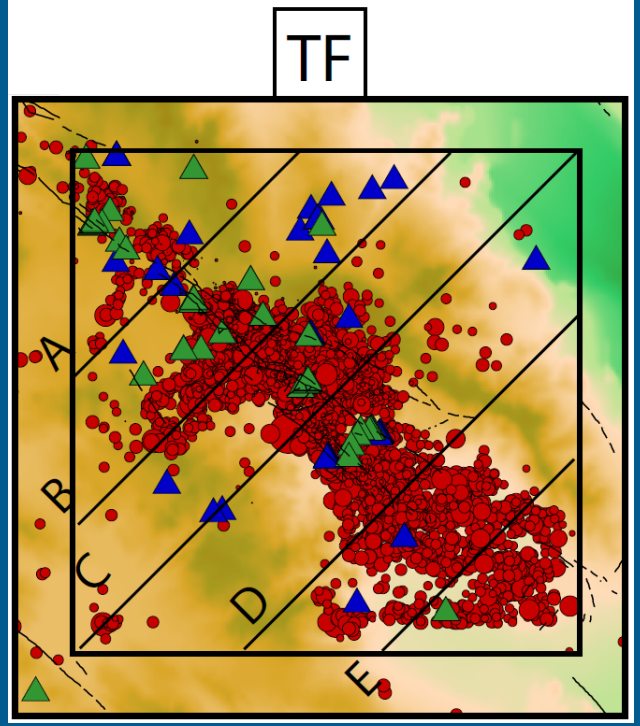
Streaming SVD - Rosenberger (2010)

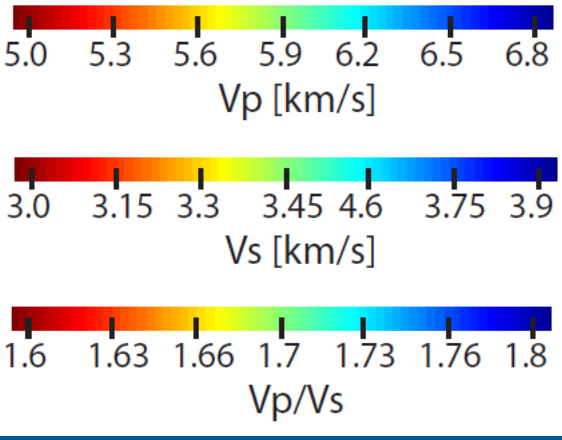
- Implement automatic detection P and S phases
- Method based on a real-time iteration algorithm of Rosenberger (2010)
- Produces incidence angle and azimuth
- Separates the waveforms into their P and S components.
- Apply filters prior to the SVD



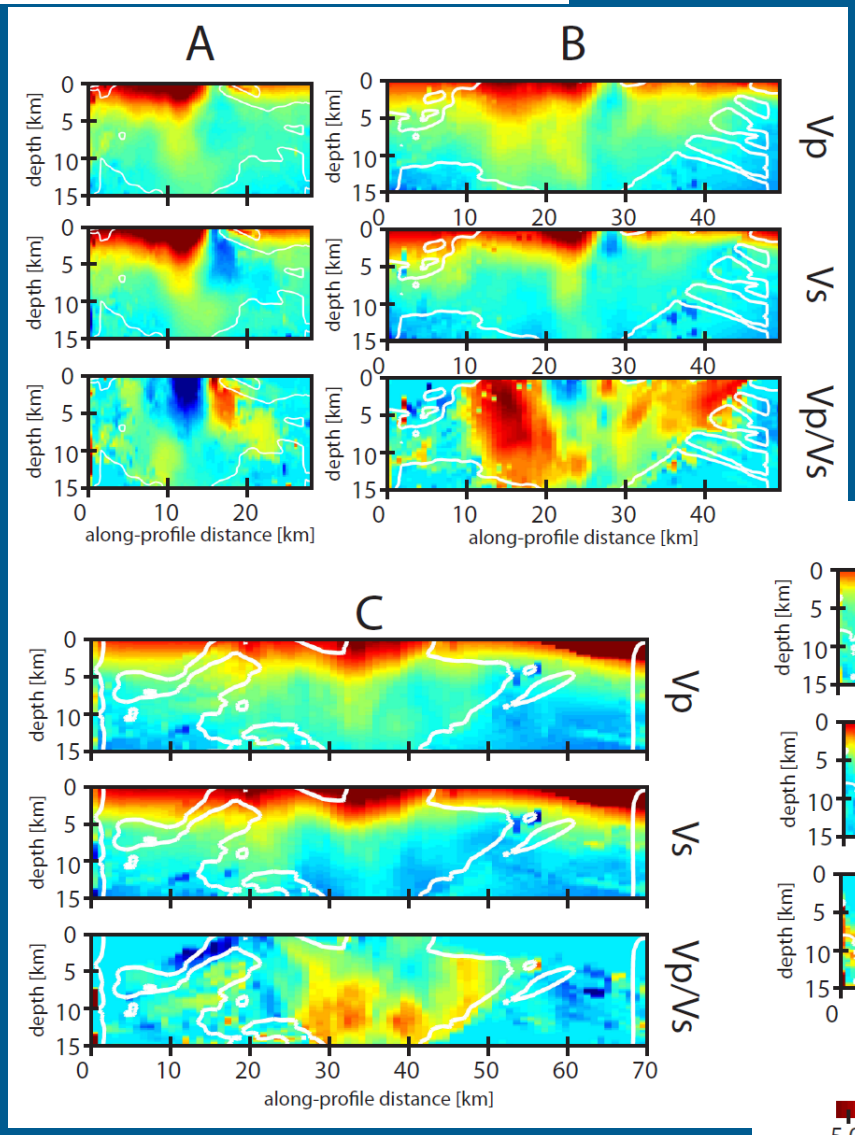
Allam et al. submitted

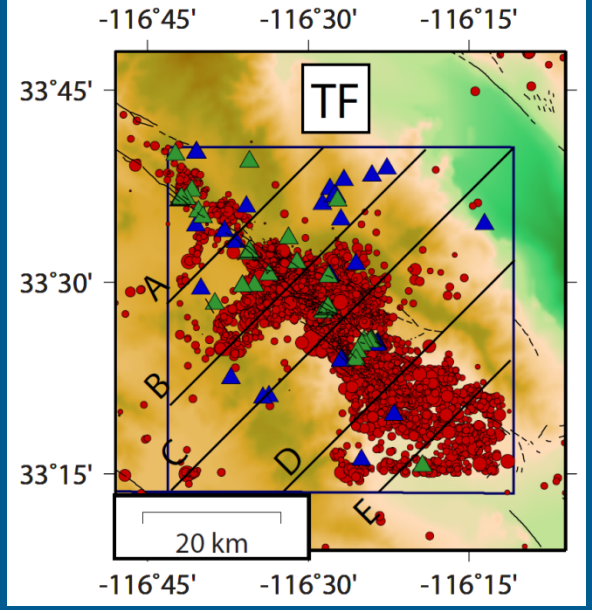


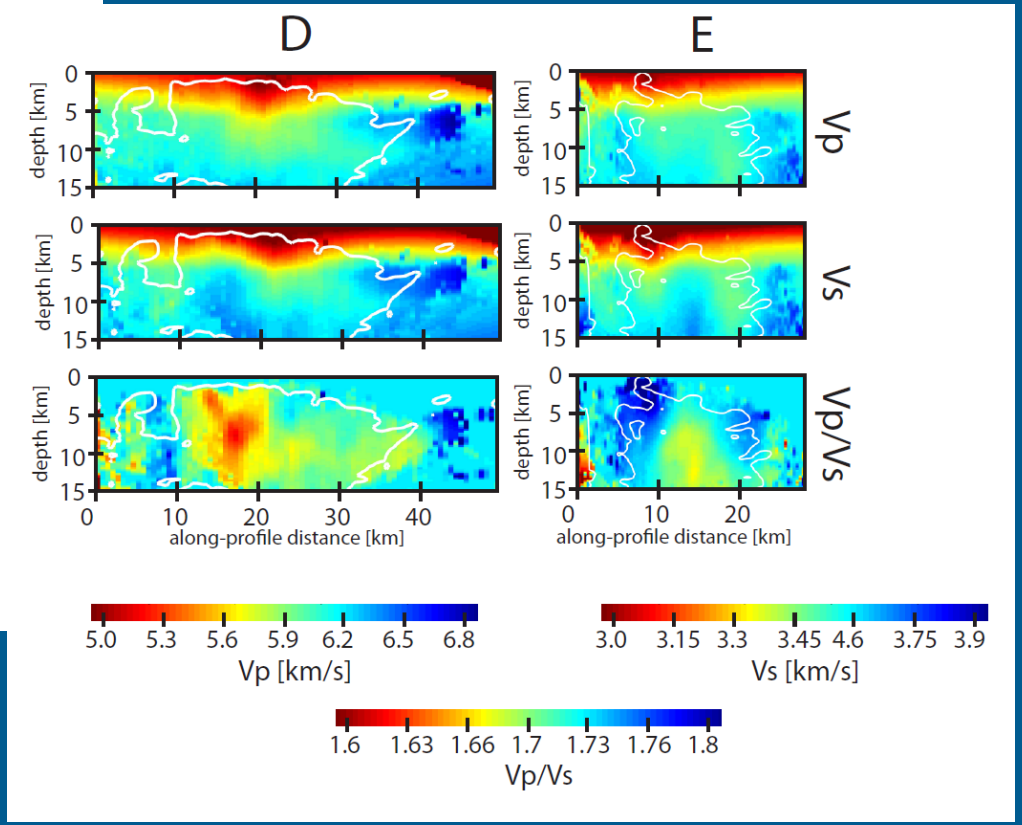


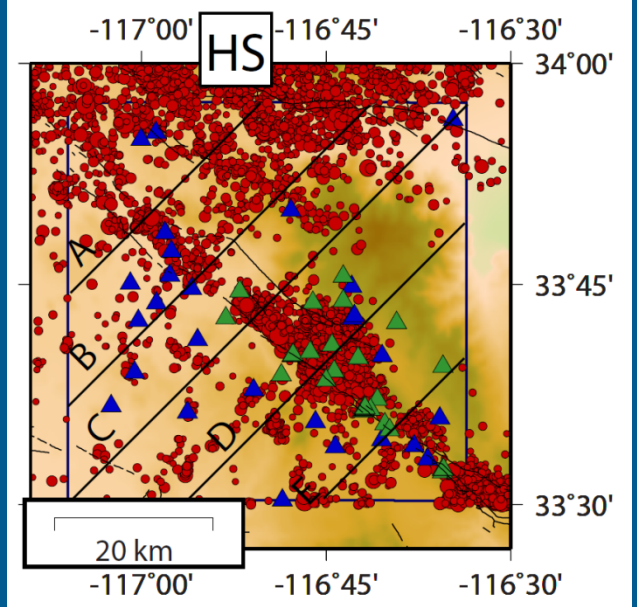


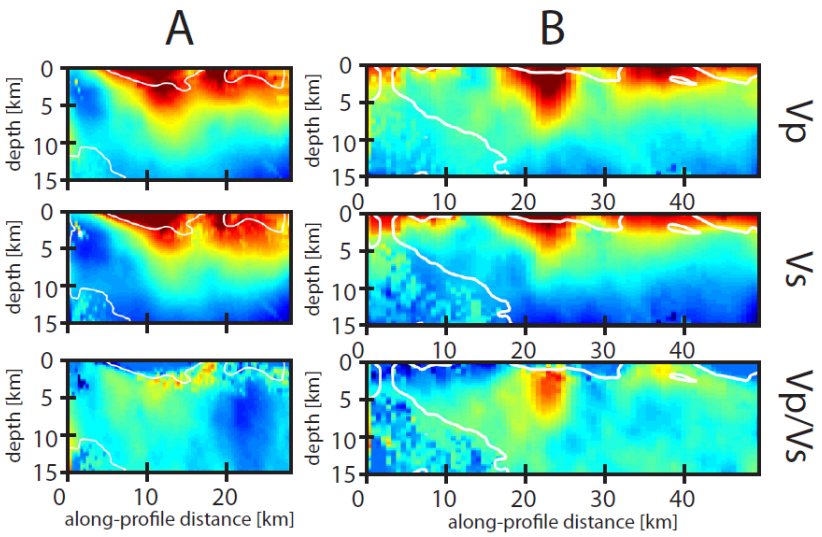
Allam et al. submitted

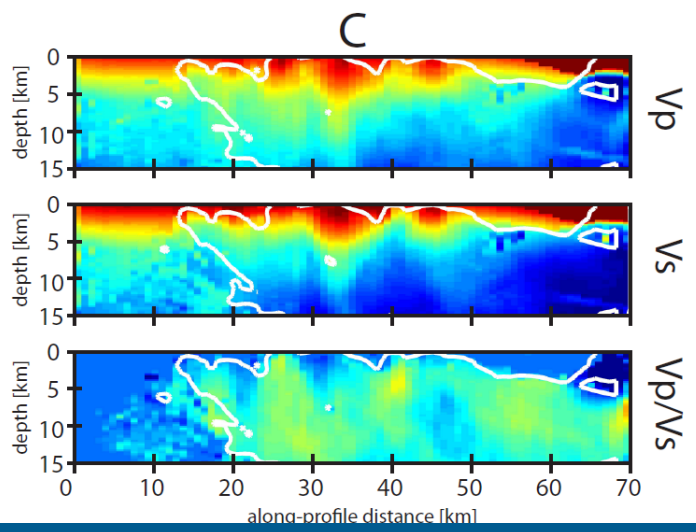

A
B
C
depth [km]
along-profile distance [km]
Vp
Vs
Vp/Vs

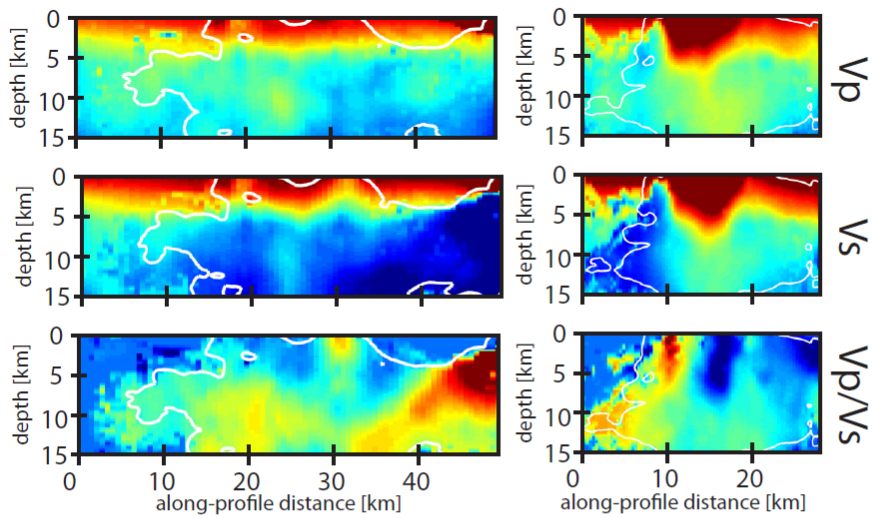

-116°45'
-116°30'
-116°15'
33°45'
33°30'
33°15'
TF
A
B
C
D
E
20 km

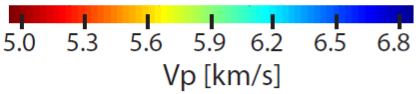

D
E
depth [km]
along-profile distance [km]
Vp
Vs
Vp/Vs
5.0 5.3 5.6 5.9 6.2 6.5 6.8
Vp [km/s]
3.0 3.15 3.3 3.45 4.6 3.75 3.9
Vs [km/s]
1.6 1.63 1.66 1.7 1.73 1.76 1.8
Vp/Vs

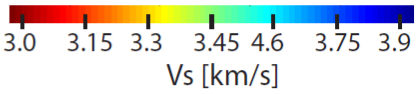

HS
-117°00'
-116°45'
-116°30'
34°00'
33°45'
33°30'
A
B
C
D
E
20 km

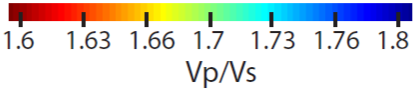

A
B
depth [km]
Vp
Vs
Vp/Vs
along-profile distance [km]

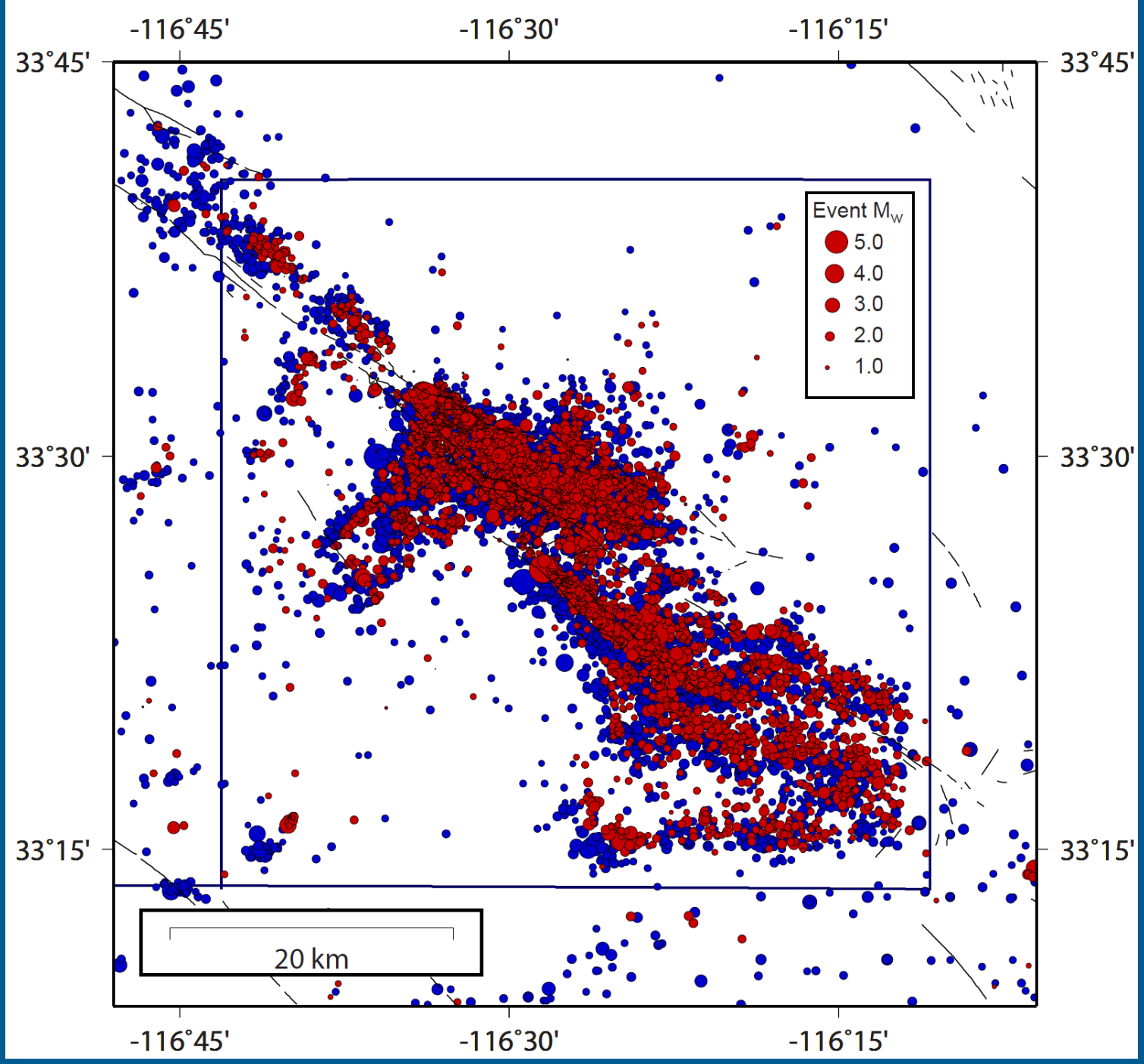

C
depth [km]
Vp
Vs
Vp/Vs
along-profile distance [km]

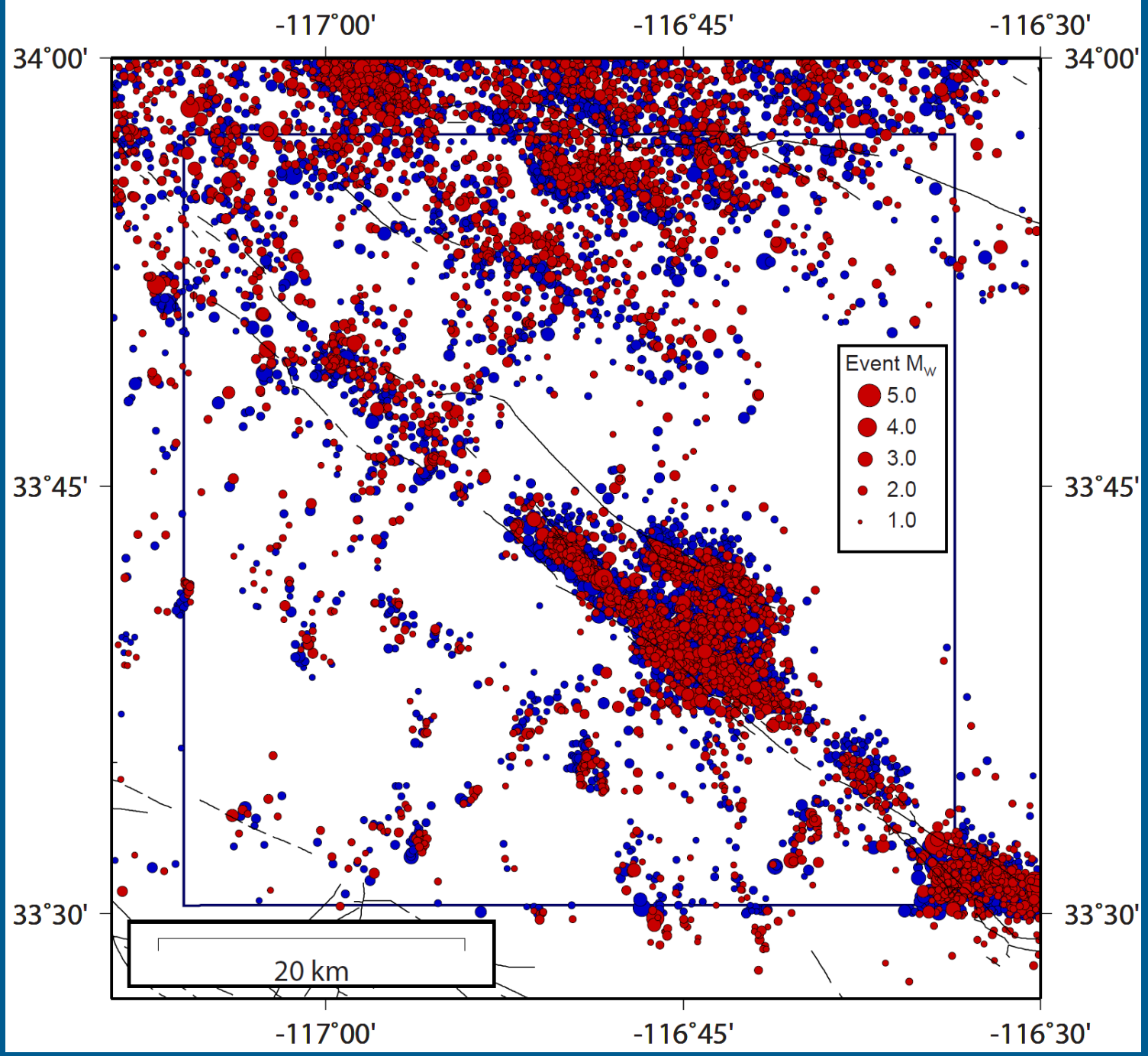

D
E
depth [km]
Vp
Vs
Vp/Vs
along-profile distance [km]


5.0 5.3 5.6 5.9 6.2 6.5 6.8
Vp [km/s]


3.0 3.15 3.3 3.45 4.6 3.75 3.9
Vs [km/s]


1.6 1.63 1.66 1.7 1.73 1.76 1.8
Vp/Vs

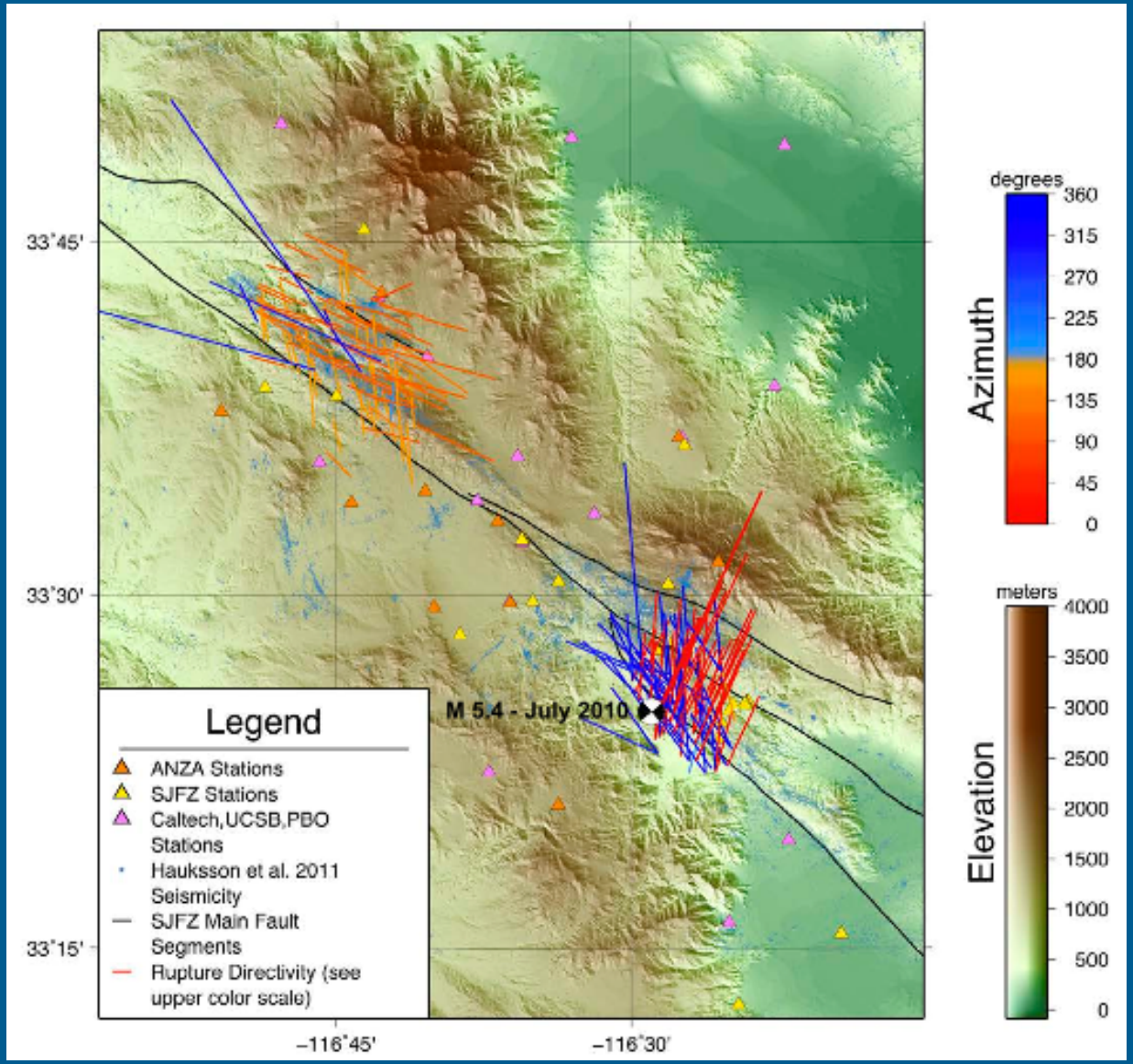

-116°45'
-116°30'
-116°15'
33°45'
33°30'
33°15'
Event M_W
5.0
4.0
3.0
2.0
1.0
20 km


-117°00'
-116°45'
-116°30'
34°00'
33°45'
33°30'
Event M_W
5.0
4.0
3.0
2.0
1.0
20 km

Directivity Observations

- M_l 5.9 July 2010 aftershocks
- Hot Springs Cluster December 2011

- Kurzon et al. submitted



GARR
HSSP
321 m
©2010 Google

Conclusions

- Tomography results
  - –Low velocity zones in faults (esp. SJFZ)
  - –Low velocity in Basins (ST, SJB, SBB)
  - –Polarity/strength of contrasts vary along fault strike
  - –Areas of Low Vp/Vs correspond to regional plutons
- Seismicity
  - –No clear connection to surface fault traces
  - –Distributed in volumes, not fault plans
- Magnitude completeness ~0.5 M
- Directivity
  - –Hot Springs cluster dominantly towards SE
  - –Trifurcation cluster either NW or N-NE (conjugate)
  - –Fault parallel directivity towards Anza Seismicity Gap