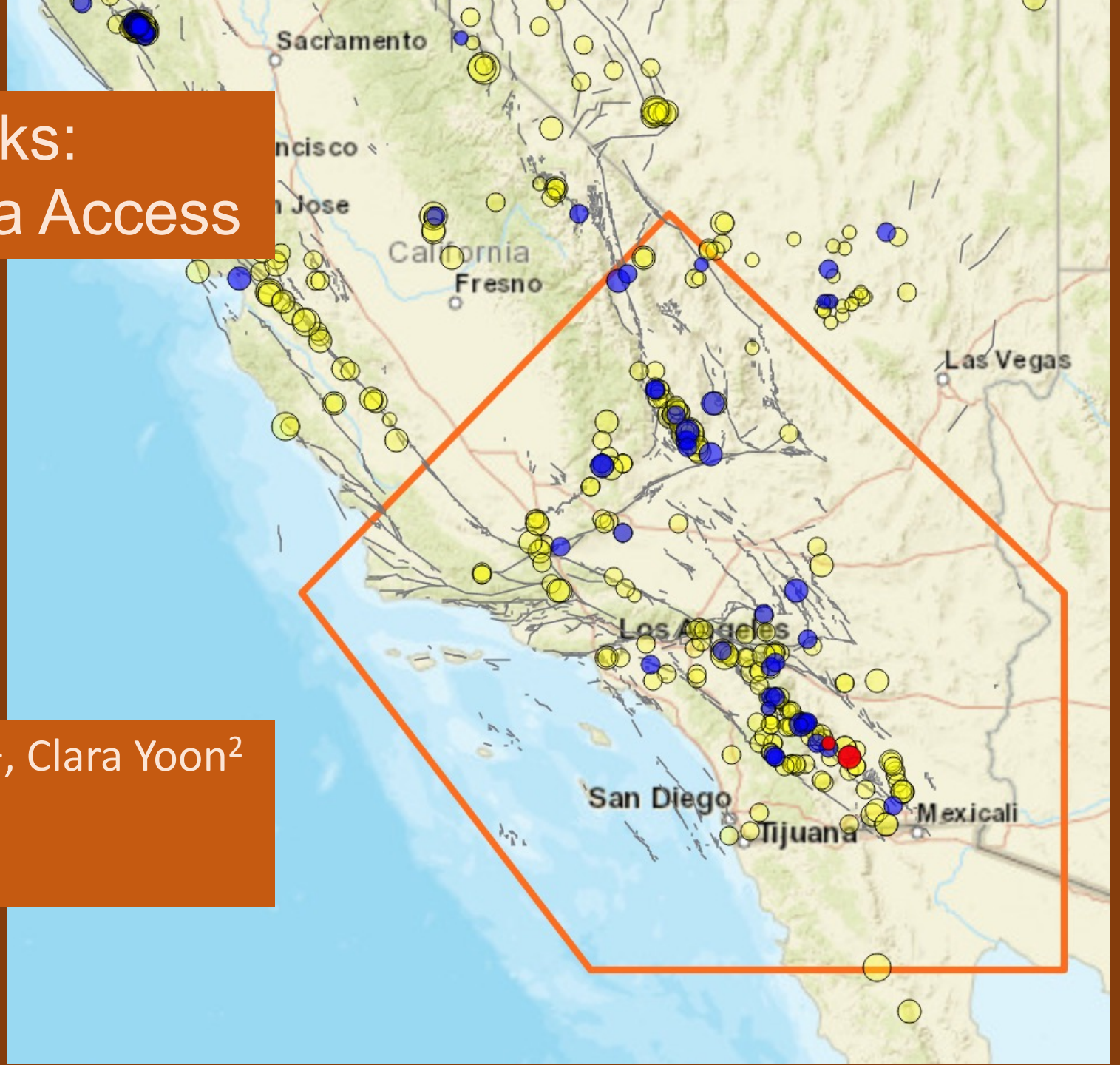
Regional Seismic Networks: Official Catalogs and Data Access



Instructors: Ellen Yu[1], Gabrielle Tepp[1], Clara Yoon[2]

[1] Caltech, Southern California Seismic Network
[2] USGS Pasadena

SCSN Caltech USGS science for a changing world ANSS Advanced National Seismic System

What We Will Cover

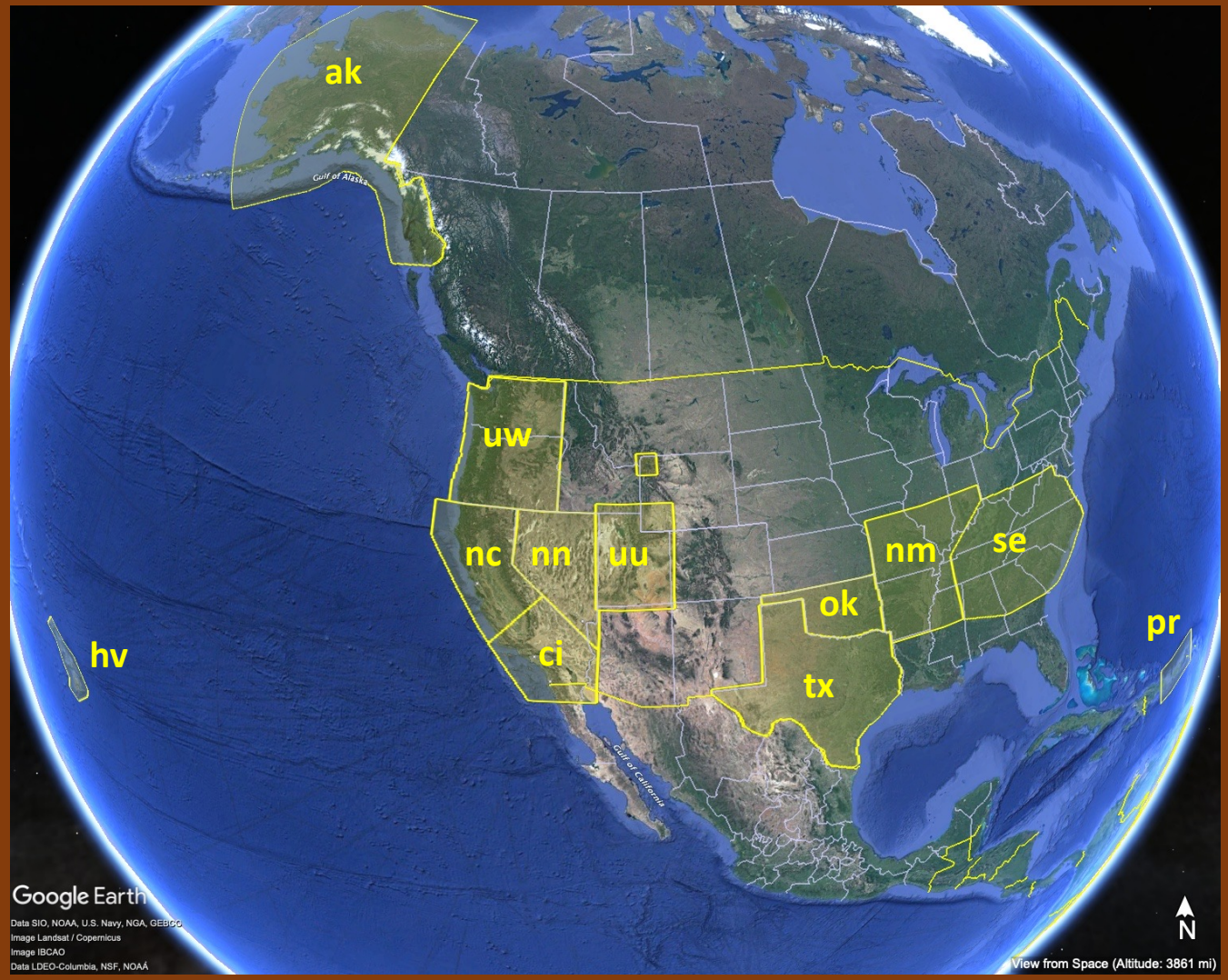
Who Produces Reference Catalogs in the US?

How Are Catalogs Produced? What Data is Collected?

How Can I Access Catalogs and Source Data?

US Regional Seismic Networks

Advanced National Seismic System:



- Group of 12 US **regional seismic networks** (RSNs)
  - Headed by USGS
  - Part of NEHRP (*National Earthquake Hazards Reduction Program)*

- What it entails:

-> Meet certain operational & data standards, so the catalog is high-quality

-> Contribute **authoritative** earthquake information in their region to ComCat (common catalog)

-> Share resources & collaborate with other RSNs

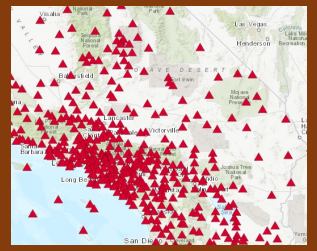
Example: Southern California Seismic Network

Southern California Seismic Network

Caltech + USGS science for a changing world

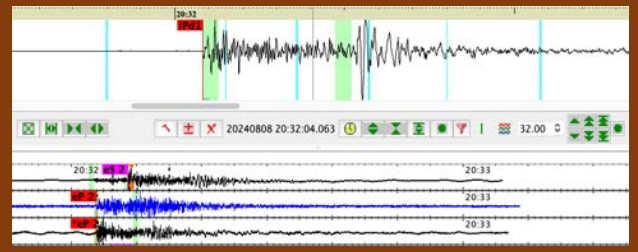
SCSN

Network Operations



- Seismic station installation and maintenance
- Telemetry
- Networking & Security
- Servers & real-time systems

Data Analysis & Seismology



- Event analysis
- Data quality checks
- Real-time system maintenance & development
- Earthquake response*
- Social media & outreach*

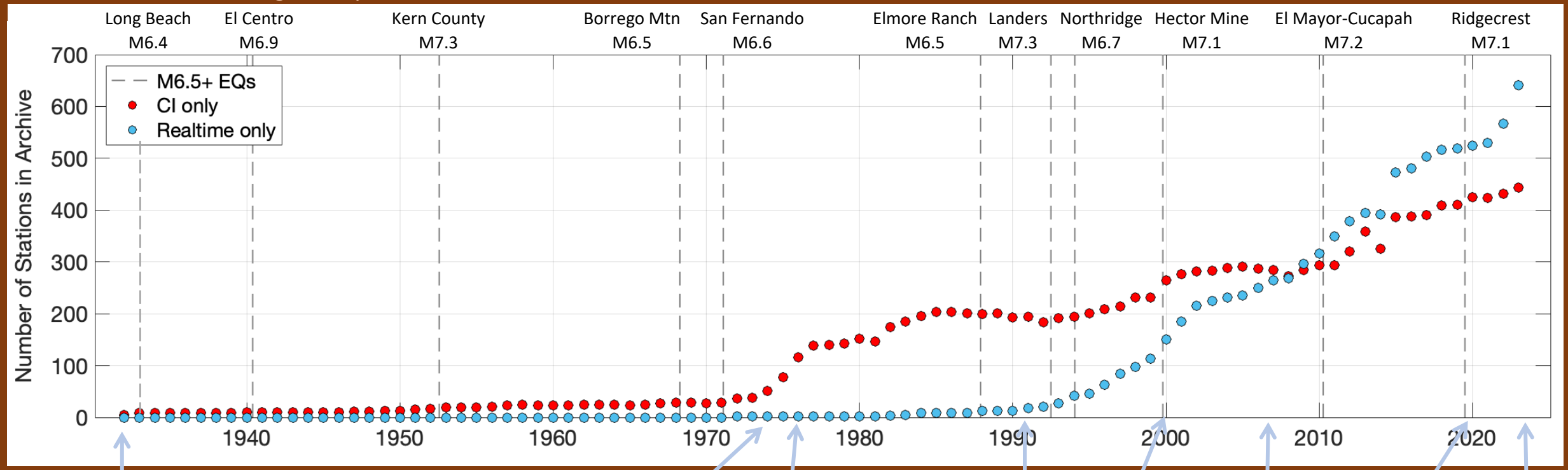
So. Cal. Earthquake Data Center (SCEDC)

- Waveform & event data archival
- Software development (real-time systems + others)
- Data quality & system checks

+ ShakeAlert EEW

SoCal Earthquakes and Monitoring History

Stations listed active during entire year



6 permanent & 2 portable stations

USGS opens office on Caltech campus

Cedar network (real-time processing) begins

SCEDC established

TriNet – digital BB array

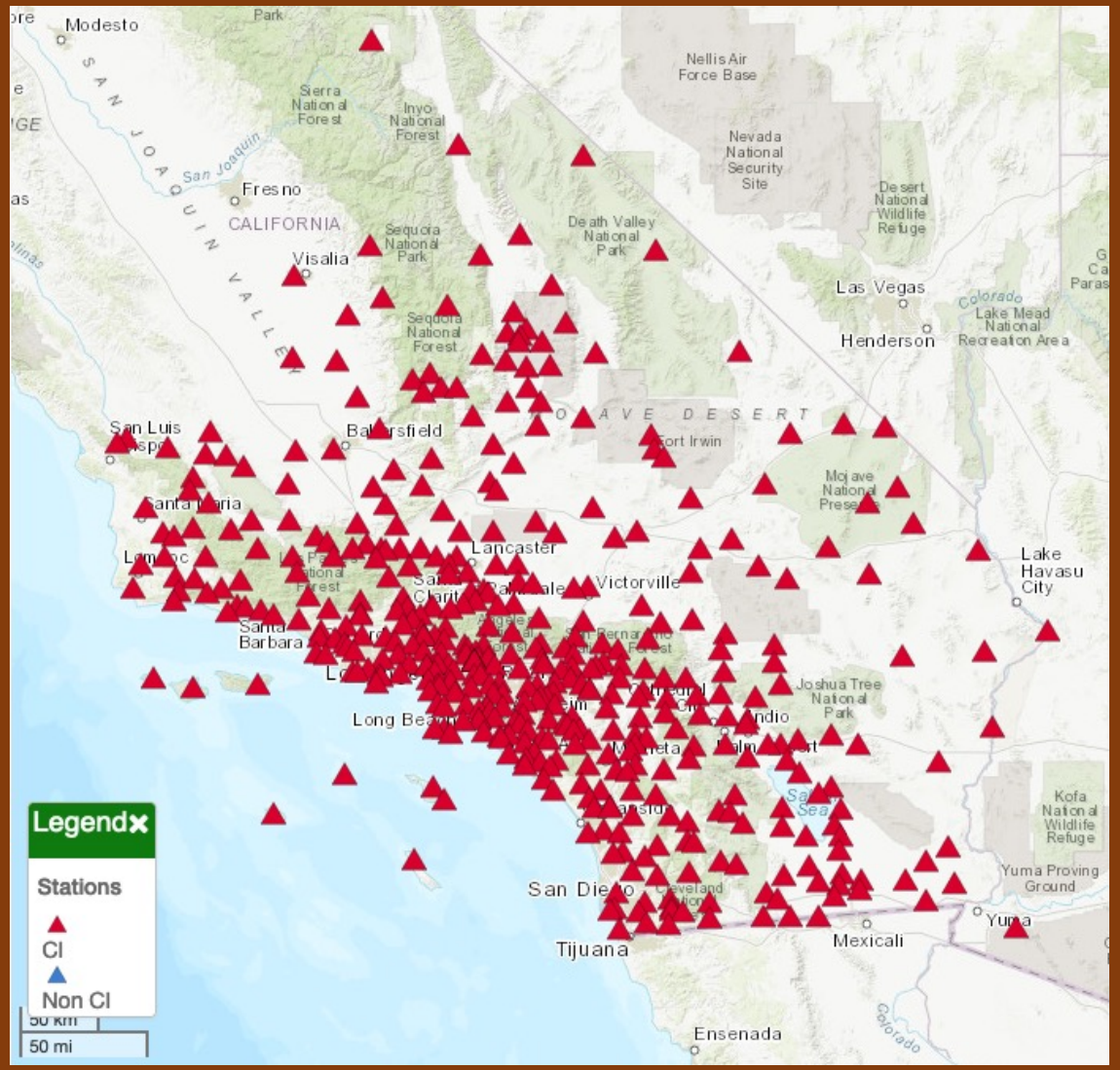
EEW project begins

EEW public statewide

Over 426 realtime digital stations

DAS work begins

Seismic Network

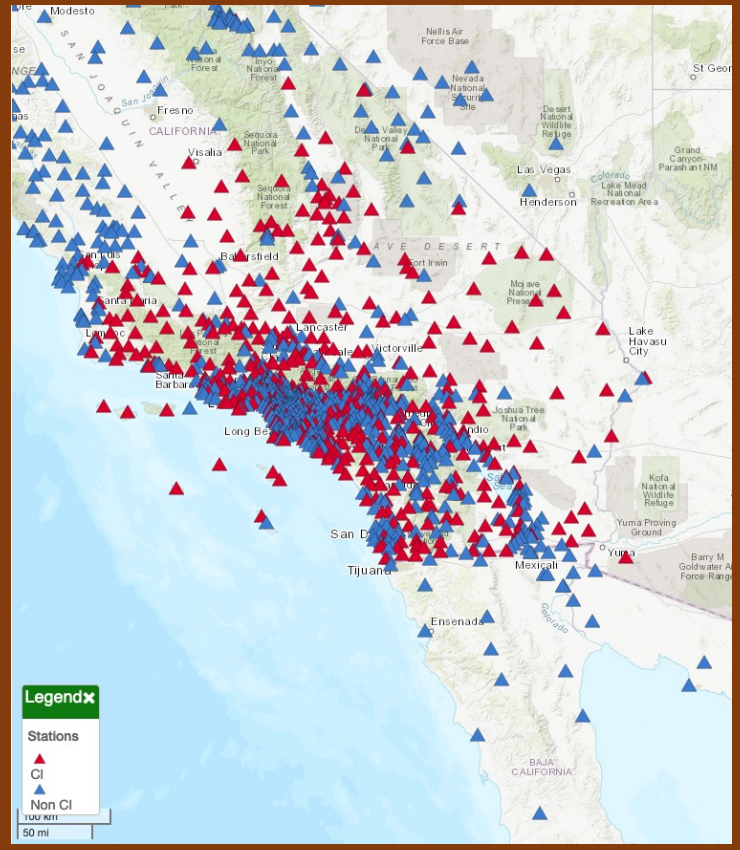


- ~662 stations used
  - 438 CI stations
  - 224 imported from other networks

* Stations not always available

- CI Stations
  - 312: broad-band & strong motion
  - 43: strong motion & vertical short-period
  - 83: strong motion only

* As of spring 2024



Citing SCSN/SCEDC Data & Services

Can also find here:

https://www.scsn.org/
-> Seismologists' Tools
-> Acknowledgment Policy

For DOIs of other networks:
https://www.fdsn.org/networks/

Cite the SCSN:
"California Institute of Technology (Caltech) (1926): Southern California Seismic Network. International Federation of Digital Seismograph Networks. Other/Seismic Network. doi:10.7914/SN/CI"

Acknowledge the SCSN:
"Data were provided by the Caltech/USGS Southern California Seismic Network (SCSN), doi:10.7914/SN/CI, operated by the Caltech Seismological Laboratory and USGS, which is archived at the Southern California Earthquake Data Center (SCEDC), doi:10.7909/C3WD3xH1"

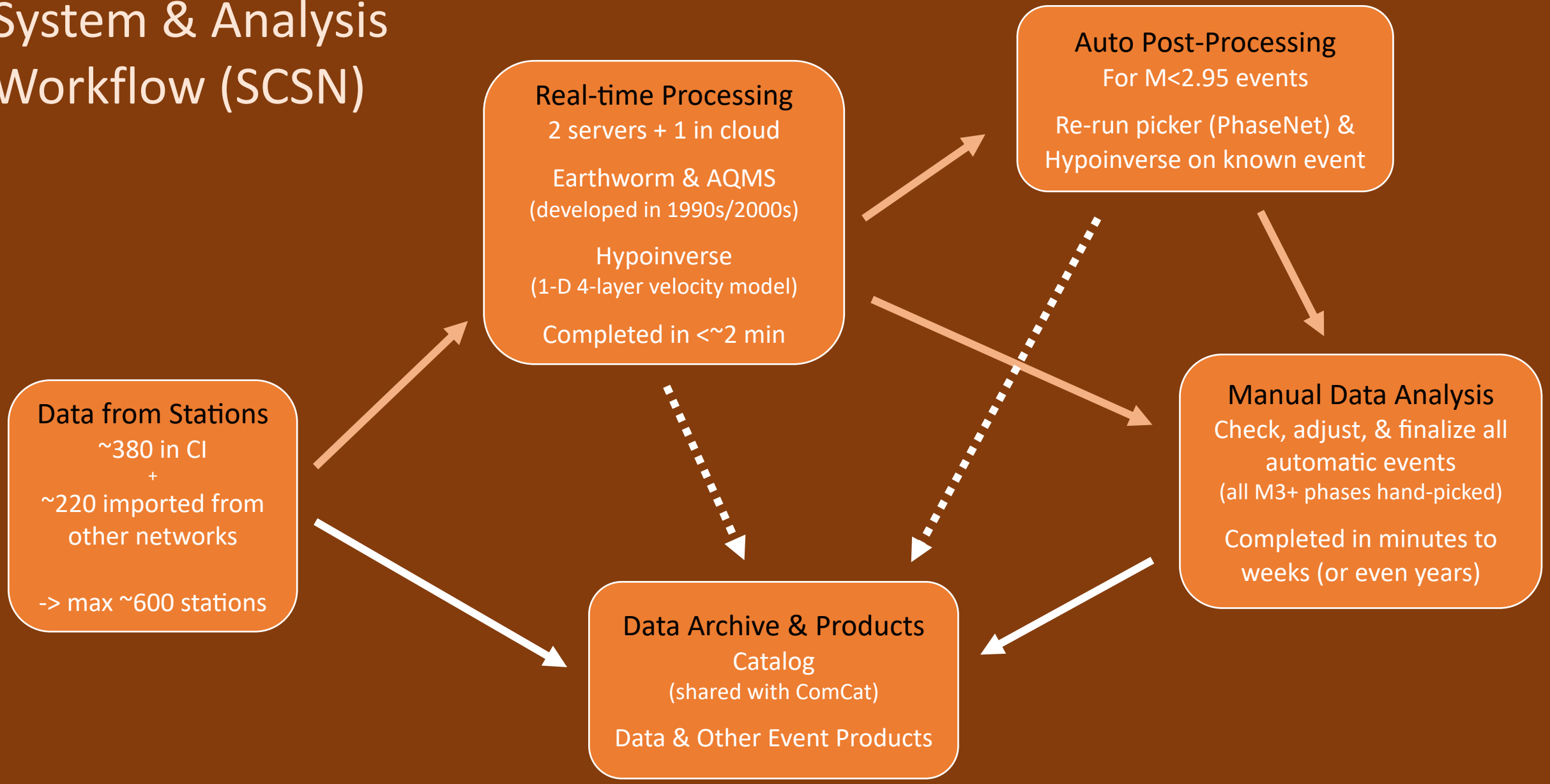
Cite the SCEDC:
"SCEDC (2013): Southern California Earthquake Center. Caltech. Dataset. doi:10.7909/C3WD3xH1"

Acknowledge the SCEDC:
"Waveform data, metadata, or data products were accessed through the Southern California Earthquake Data Center (SCEDC), doi:10.7909/C3WD3xH1"
"The SCEDC and SCSN are funded through U.S. Geological Survey Grant G10AP00091, and the Southern California Earthquake Center, which is funded by NSF Cooperative Agreement EAR-0529922 and USGS Cooperative Agreement 07HQAG0008."

Please insert the preceding sentences into your publication acknowledgments.

EQ Monitoring & Catalog Data

Current Real-time System & Analysis Workflow (SCSN)

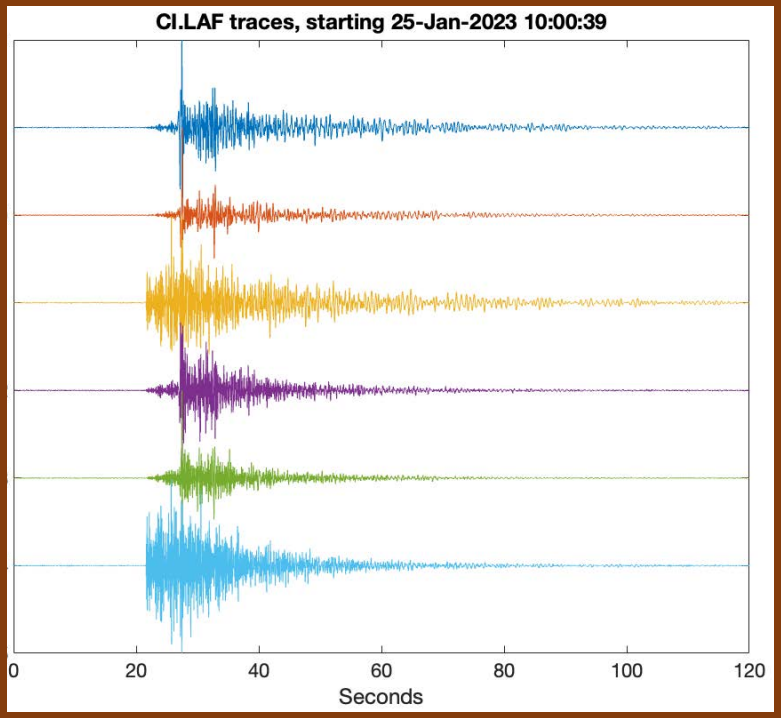


Waveforms

- Collected in real-time
  - CI network code (SCSN)
  - continuous data
  - stations not always available/running
  - data completeness is variable
    - buffers can fill in data up to ~1 week - ~1 month

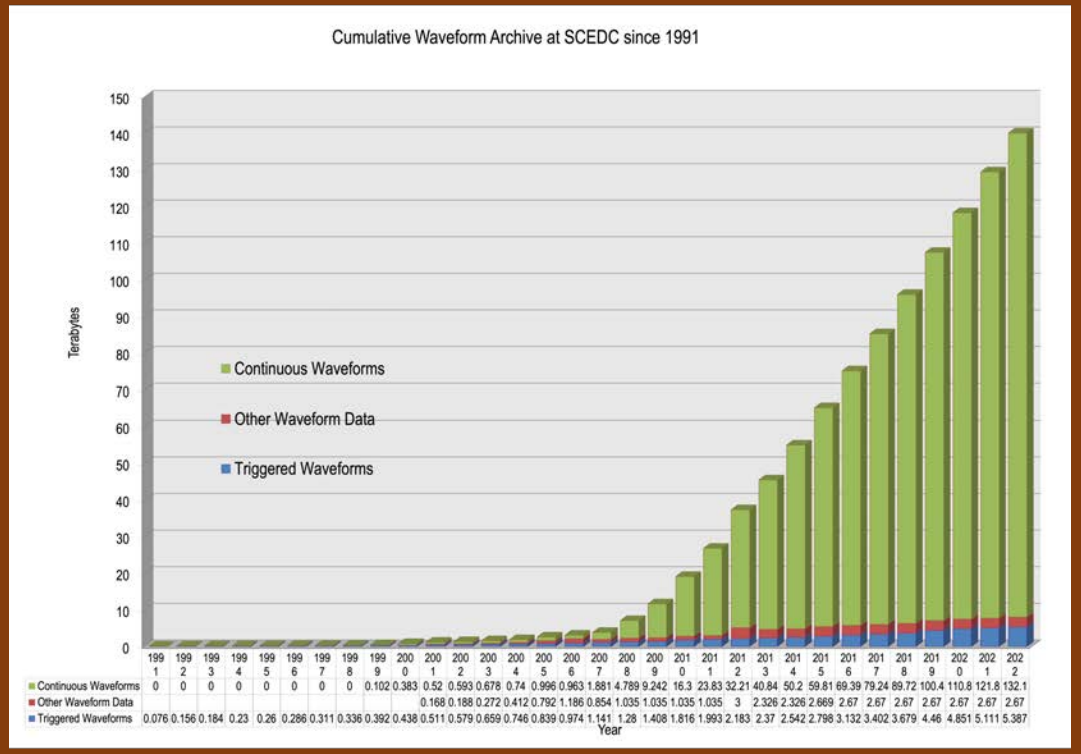
- Data types (SCSN)
  - Strong motion: most common sensor in network
    - sampled at 100 sps
  - Broad-band: second most common
    - sampled at 40 & 100 sps
  - Short-period: few remaining, more common in past
    - sampled at 100 sps

* Some networks may have other data types (e.g., GNSS, infrasound)

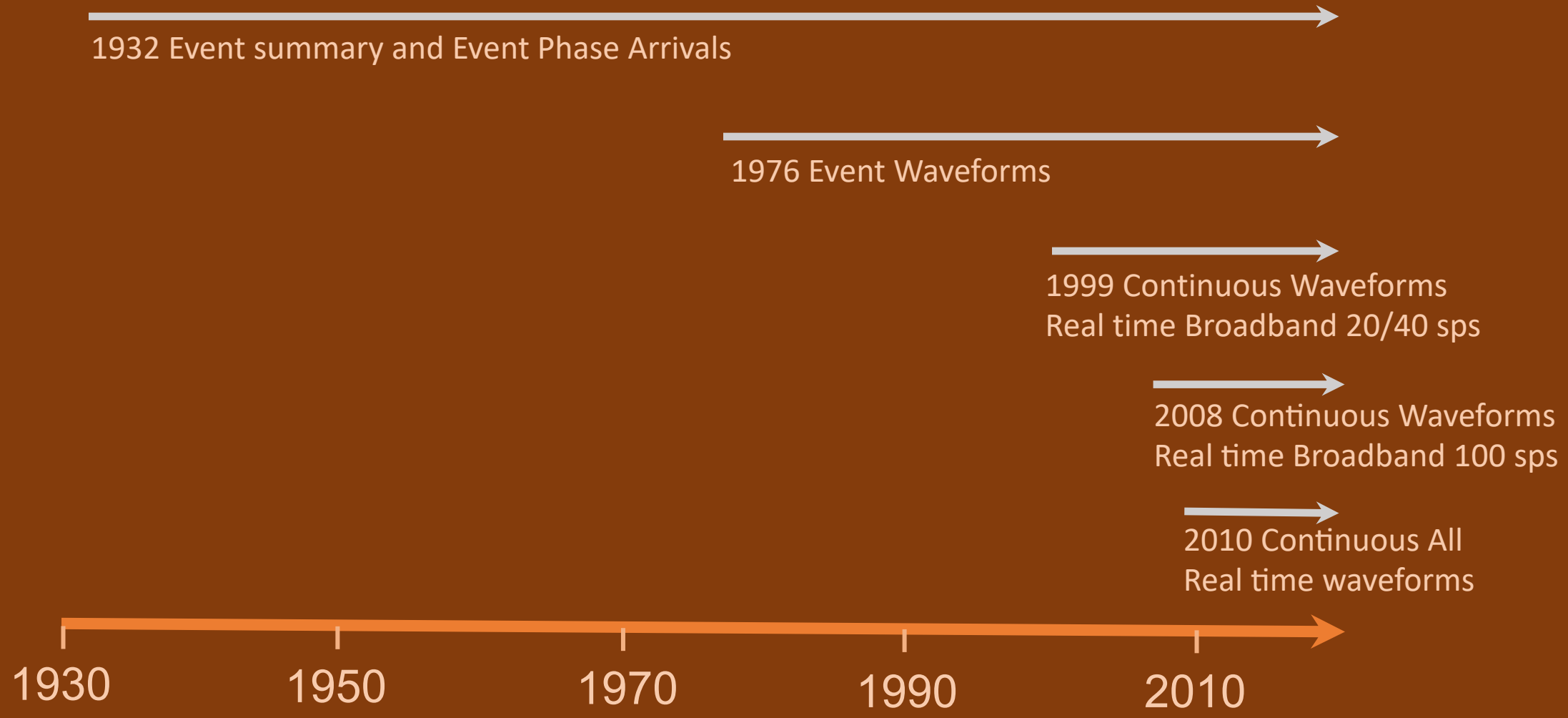


Waveforms - Archival

- Archived at SCEDC (subset of this data is at Earthscope)
  - miniSEED is our native archival format
  - An automated process detects gaps and tries to contact the digitizer to fill them in
  - Data for some stations are triggered only (i.e., only event waveforms)
    - Typically non-CI stations (e.g., NP, CE)
  - No other processing done
  - ~33 GB/day -> 12TB/yr
  - Over 280 TB distributed in 2023: 23+ bytes distributed for every byte recorded

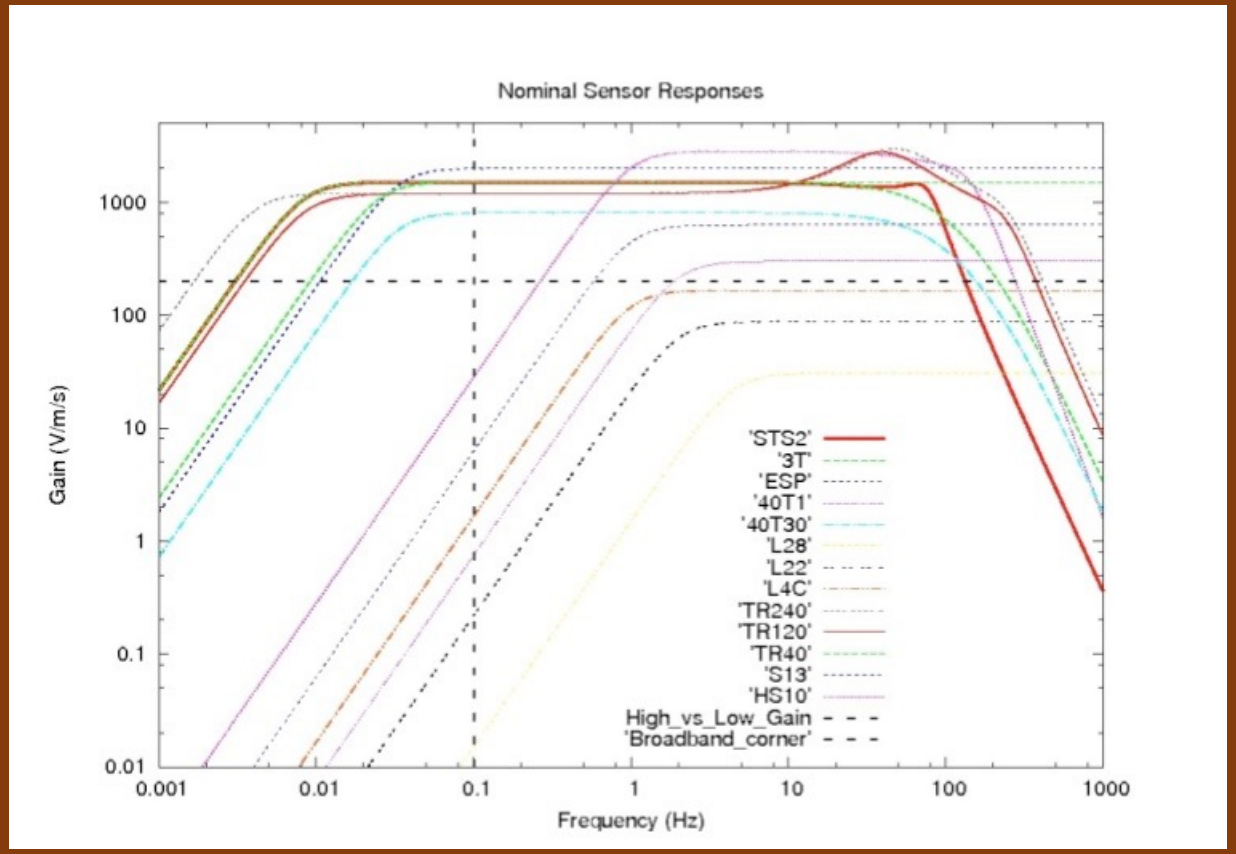


SCEDC/SCSN Archival Policy Over Time



Station Metadata

- FDSN* StationXML, dataless SEED, one line summary formats
- Most broadband sites use nominal response from Nominal Response Library
- Quality control
  - ensure correct format and internally consistent
  - passes the IRIS/EarthScope validator
  - flag any change of response for channels contributing to early warning systems



From Passcal Instrument Center

FDSN* = International Federation of Digital Seismograph Networks

https://www.fdsn.org/

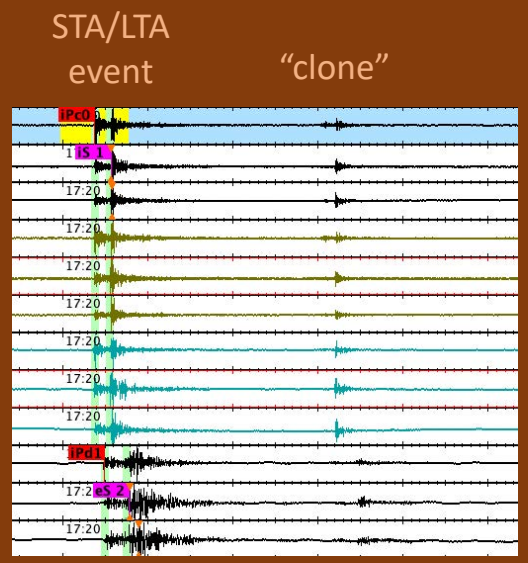
Most Common seismic channel names
HH – 100 sps, broadband
HN – 100 sps strong motion
EH – 100 sps short period
BH – 40 sps broadband
LH – 1 sps broadband

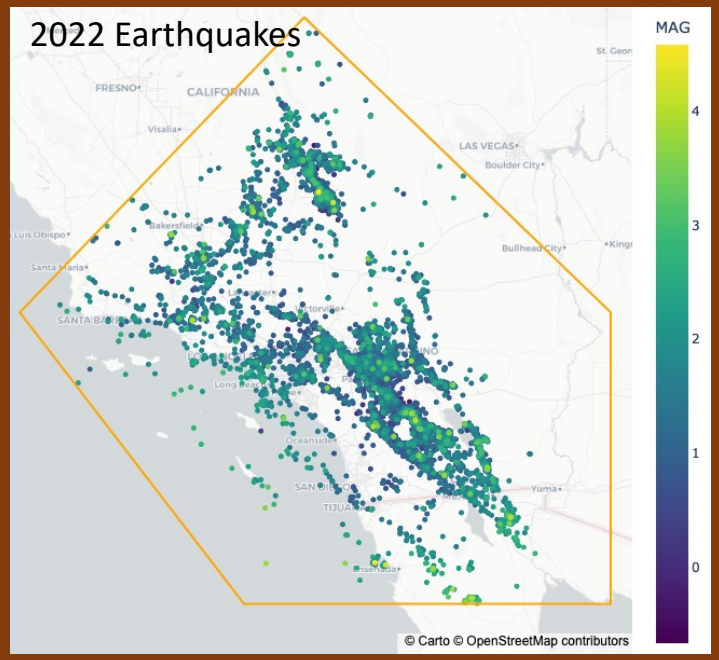
Earthquake Catalog

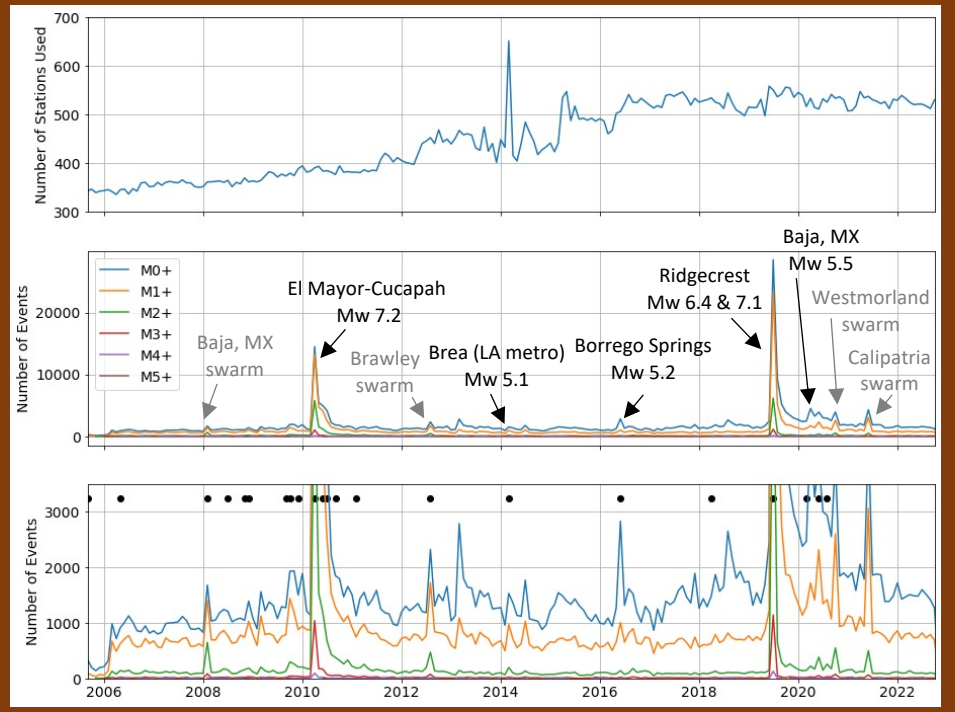
- Mostly consists of events found with STA/LTA
  - full network & subnet triggers (i.e., collections of nearby unassociated picks)
  - analysts can manually add events (generally by “cloning” other events in window)

- All events are reviewed by analysts
  - not regularly reviewed outside work hours or during holiday breaks
  - M2.5+ prioritized
  - note: this may change in the future

- Note: Different networks may have different procedures!
  - Example: see R. Hartog talk, 2:30p 4/15





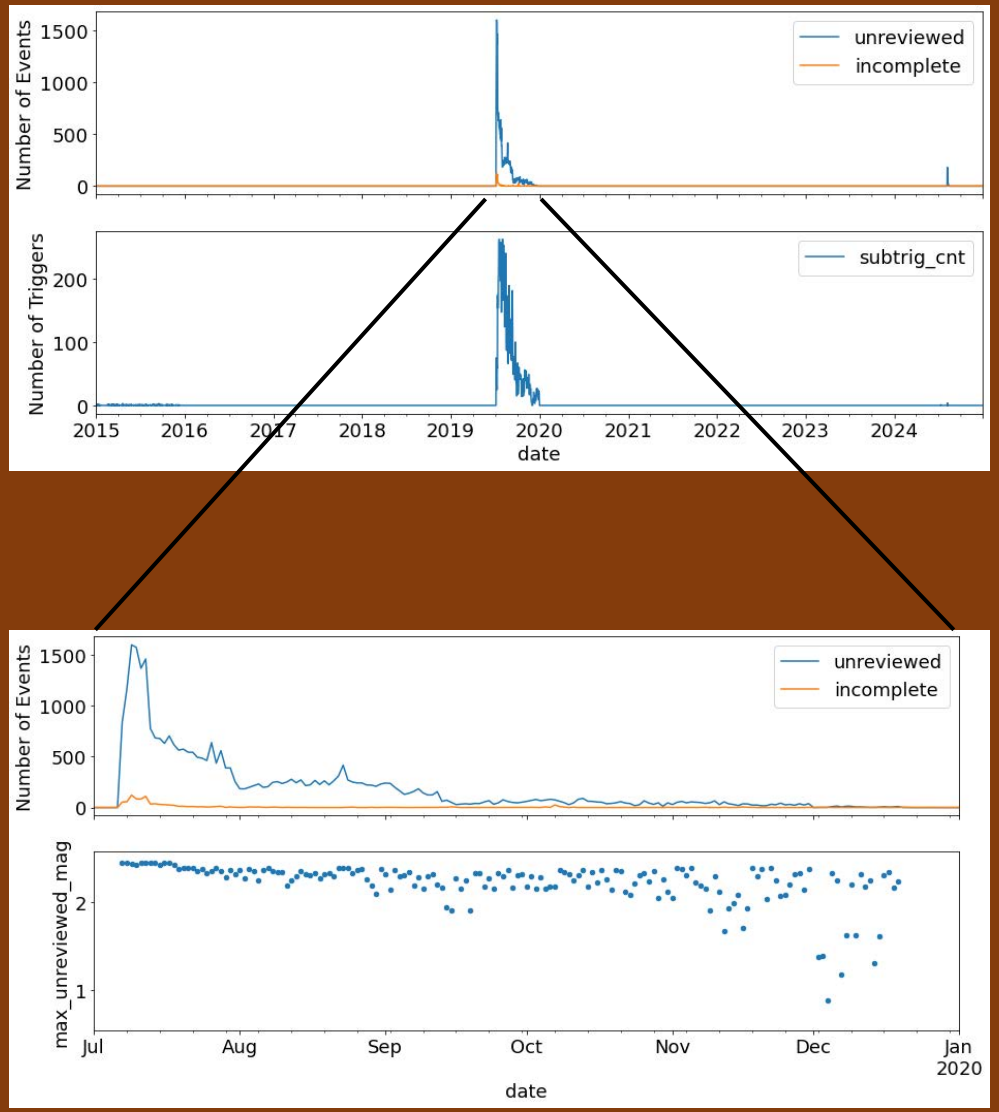


Earthquake Catalog

- Full catalog goes back to 1932
  - “modern” catalog starts around 1990s/2000s
  - multiple catalog transitions
  - 961,000+ events
  - For more info, check out Poster #32 on 4/15!

- Incomplete: July – December 2019
  - Ridgecrest sequence approx. complete to M2.5
    - July 4-6 fully reviewed
  - current focus is to finish late 2019
  - review status files available from SCEDC:
    - https://service.scedc.caltech.edu/ftp/catalogs/catalog_status/
    - https://github.com/SCEDC/SCEDC-catalog-status/

** Regional catalogs (including ComCat) change over time – when using, be sure to note the download date!



Earthquake Catalog (SCEDC)

https://service.scedc.caltech.edu/eq-catalogs/date_mag_loc.php

Event type (ET)
eq: earthquake
qb: quarry blast
nt: nuclear test
uk: unknown
+ others

Geographic type (GT)
l: local
r: regional
t: teleseism

Magnitude (MAG & M)
l: local
lr: corrected local (SCSN M>3.5)
w: moment
d: duration
e: energy

Hypocenter
(LAT [deg], LON [deg], DEPTH [km])

Quality (Q)
A is best

Event ID
(EVID)

Comments from analyst

Number of
phases (NPH)
- P & S picks

Number of event
waveforms available

Origin time
(UTC)

#YYY/MM/DD HH:mm:SS.ss	ET	GT	MAG	M	LAT	LON	DEPTH	Q	EVID
2023/03/06 04:37:29.14	eq	l	0.35	l	33.486	-116.400	12.5	A	40421392
2023/03/06 04:38:43.63	eq	l	1.95	l	32.643	-115.724	9.9	A	40421400
2023/03/06 04:50:21.47	eq	l	0.51	l	33.765	-116.929	10.7	A	40421408
2023/03/06 06:11:39.95	eq	l	0.64	l	33.468	-116.553	8.6	A	40421416
2023/03/06 08:25:38.38	eq	l	1.36	l	34.045	-118.937	10.7	B	40421424
2023/03/06 09:17:14.03	eq	l	1.41	l	34.324	-118.500	7.3	A	40421432
2023/03/06 09:27:07.06	eq	l	1.07	l	33.399	-116.386	2.4	A	40421440
2023/03/06 09:34:43.69	eq	l	1.25	l	33.991	-118.339	9.2	A	40421448
2023/03/06 09:48:56.80	eq	l	1.17	l	34.457	-117.954	8.9	A	40421456
2023/03/06 12:05:54.76	eq	l	1.51	l	32.983	-115.525	6.0	A	40421480
2023/03/06 12:46:15.72	eq	l	1.36	l	34.023	-116.740	15.9	A	40421488
2023/03/06 13:01:37.18	eq	l	1.26	l	35.506	-118.391	8.6	A	40421496
2023/03/06 17:29:52.47	eq	l	1.29	l	35.804	-117.627	6.1	A	40421512
2023/03/06 17:40:07.96	eq	l	0.31	l	33.671	-116.686	16.1	A	40421520
2023/03/06 18:11:35.09	eq	l	1.43	l	35.644	-117.385	10.3	A	40421528
2023/03/06 18:20:11.62	eq	l	2.72	l	35.617	-117.537	7.6	B	40421536
2023/03/06 19:34:27.21	eq	l	0.63	l	33.502	-116.779	4.3	A	40421552
2023/03/06 19:34:50.65	eq	l	1.20	l	33.930	-116.788	18.6	A	40421560
2023/03/06 22:45:51.61	eq	l	0.66	l	33.528	-116.727	4.8	A	40421576

REMARKS

OR

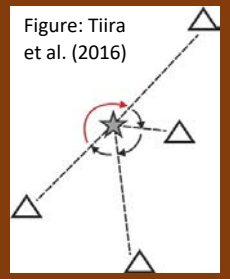
NPH	NGRM
31	1281
33	1961
14	991
26	1401
16	1797
33	2373
53	1761
31	2603
30	2233
12	1294
56	2347
20	1793
23	2611
8	1988
19	1962
6	2157
13	1098
52	2197
30	1340

SCSN with comments

SCEDC

Other formats
also available!

Earthquake Catalog (ComCat)



Largest azimuthal gap between stations (gap)
- in degrees
- lower is better

Root mean square error of origin (rms)
- overall indicator of event/pick quality
- aim to keep this below ~0.3

Hypocenter errors
- aim to keep below 1-2 km
- depth error often higher, especially if depth is fixed

Number of stations used for mag

Distance to closest station (dmin)
- in degrees
- lower is better

Relative location of event (place)

Error/uncertainty of magnitude

Event status
- automatic
- reviewed

Preferred/authoritative network (net), first 2 letters of event id (id)
- ci is SCSN

Number of stations with phase picks (nst)

Time of last event update (UTC)

Contributor of hypocenter & magnitude

time	latitude	longitude	depth	mag	magType	nst	gap	dmin	rms	net	id	updated	place	type	horizontalErr	depthError	magError	magNst	status	locationSour	magSource
2023-03-05T	32.9391667	-115.82683	11.02	2.09	ml	49	41	0.01571	0.25	ci	ci40421224	2023-03-06T23:36:34.90(	22km WSW	earthquake	0.26	0.53	0.23	24	reviewed	ci	ci
2023-03-05T	33.4031667	-116.39567	6.31	2.13	ml	91	30	0.07988	0.16	ci	ci40421056	2023-03-06T20:31:24.21(	16km N of B	earthquake	0.13	0.37	0.147	26	reviewed	ci	ci
2023-03-04T	36.2491667	-117.86433	-1.45	2.39	ml	27	56	0.1315	0.19	ci	ci40420784	2023-03-05T20:50:17.382	13km ESE of	earthquake	0.21	0.5	0.133	38	reviewed	ci	ci
2023-03-03T	33.018	-116.35267	9.49	2.1	ml	64	47	0.06705	0.23	ci	ci40420560	2023-03-04T01:54:43.33(	24km ESE of	earthquake	0.22	0.67	0.188	25	automatic	ci	ci
2023-03-03T	33.489	-116.78683	3.71	2.16	ml	85	17	0.0259	0.19	ci	ci40420528	2023-03-04T01:45:36.42(	9km NE of A	earthquake	0.13	0.4	0.149	26	reviewed	ci	ci
2023-03-01T	33.4858333	-116.47817	11.19	2.33	ml	80	35	0.05767	0.19	ci	ci40419944	2023-03-02T16:07:38.02(	20km ESE of	earthquake	0.13	0.34	0.143	66	reviewed	ci	ci
2023-02-28T	35.6128333	-117.4165	8.15	3.56	ml	37	41	0.09739	0.15	ci	ci40419496	2023-03-02T12:35:13.585	17km SSW o	earthquake	0.15	0.53	0.187	120	reviewed	ci	ci
2023-02-28T	32.7465	-117.38233	15.73	2.37	ml	44	220	0.1185	0.14	ci	ci40419488	2023-02-28T19:48:47.624	15km SW of	earthquake	0.35	0.28	0.158	61	reviewed	ci	ci
2023-02-28T	35.6136667	-117.4145	7.92	3.15	ml	38	41	0.04739	0.16	ci	ci40419408	2023-03-01T03:08:40.04(	17km S of Tr	earthquake	0.18	0.39	0.169	90	reviewed	ci	ci

** Cheat sheet: https://earthquake.usgs.gov/data/comcat/

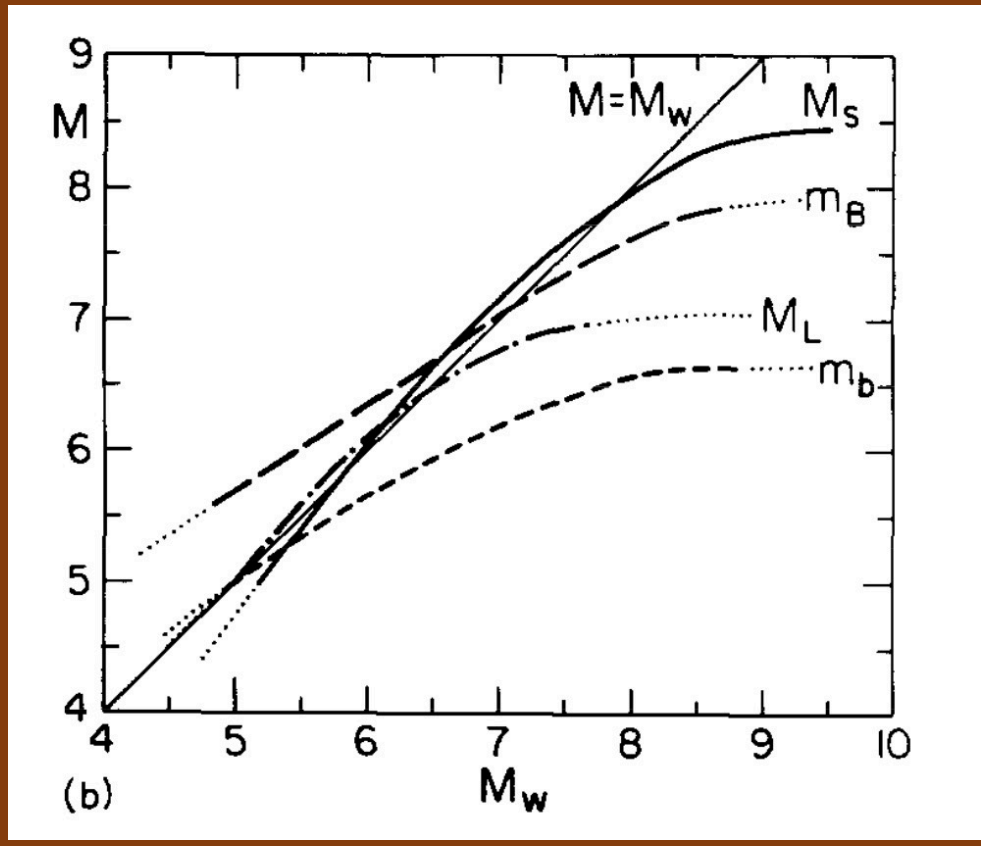
Magnitudes: Many different scales

- M_L: local magnitude (preferred for M<3.5 at SCSN)
  - Measure peak amplitude; for small nearby earthquakes
  - SCSN uses California Integrated Seismic Network M_L (Uhrhammer et al. 2011, BSSA)
- M_d: duration magnitude (preferred for M<3, selected regions)
  - Measure shaking duration from time decay of coda; useful for clipped records
  - Sometimes only available magnitude for smaller earthquakes (M<3 Northern CA)
- M_w: moment magnitude (preferred for M>3.5 at SCSN)
  - Measure low-frequency from larger earthquakes; often from moment tensor inversion
- M_{ww}: W-phase moment magnitude (M>6 for ANSS networks)
  - Very low-frequency, early arrival (before S-wave), stable measurement: rapid magnitude for largest earthquakes (helpful for tsunami warning)
  - Authoritative M_{ww} calculated by USGS National Earthquake Information Center
- M_e: energy magnitude
  - Measure radiated energy from integrated waveform; automatic at SCSN but not preferred
- M_h: hand-edited magnitude (placeholder to modify later)
- Others (mostly for regional/teleseismic distances)
  - M_s: magnitude from surface waves
  - m_b: magnitude from body waves
  - Mwc, Mwb, Mwr, Mfa, Mwp
- **"Preferred" magnitude** reported in ComCat: check magnitude type!
  - But ComCat also has non-preferred magnitudes.

M_{Lr} : revised local magnitude for SCSN

$M_{Lr} = 0.853M_L + 0.40125$, $3 < M_L < 6$

* don't use this for research



Magnitude saturation

Kanamori (1983)

https://www.usgs.gov/programs/earthquake-hazards/magnitude-types

Details | Phases | Magnitudes

Magnitudes

https://earthquake.usgs.gov/earthquakes/eventpage/ci40161279/origin/magnitude

preferred **magnitude**: M_w

Mw

4.19		6	CI
Mag	Err	Stations	Source

No station details contributed

Station information?
See moment tensor

Ml

4.46	0.161	260	CI
Mag	Err	Stations	Source

Station Details +

Mlr

4.19	0.168	279	CI
Mag	Err	Stations	Source

Non-preferred magnitude: M_{Lr}

Station Details −

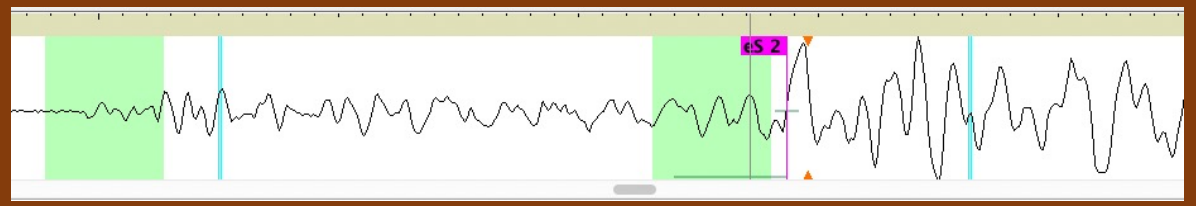
Download ← Download station amplitudes & magnitudes in csv format

Notice variation in station-specific magnitude values

Station Magnitude Details

Channel	Type	Amplitude	Period	Status	Magnitude	Weight
CI BTP HHE	MLR	–	–	automatic	4.38	1
CI HOL HHN	MLR	–	–	automatic	4.88	1
CI CYP HHE	MLR	–	–	automatic	4.06	0
CI MSJ HHN	MLR	–	–	automatic	4.89	1
CI TOW2 HHE	MLR	–	–	automatic	4.40	1
PG EFD HNN	MLR	0.0032570 m	–	manual	4.40	0
CI STG HHE	MLR	–	–	automatic	4.44	1
CI DTP HHN	MLR	–	–	automatic	4.68	1
CI GLA HHN	MLR	0.00081037 m	–	manual	4.21	1
CI VDJ HHN	MLR	0.0037160 m	–	manual	4.83	0
CI DGR HHE	MLR	–	–	automatic	4.46	1

Phase Picks



Analyst approach:

- make as many phase picks as possible
- stop at ~100 km distance
- skip low quality picks, unless necessary

*Note – not all stations that recorded the event may have picks

HYPOINVERSE format

Event info

```
20230125100054683 3 5310118 4227 1471   262134 16  2434185  35220 2  25        13  107  25  35 83   0                  287 w419           40161279w419
PTD  CI VHHZ iPU1202301251000 5822 -20 02   00      00          00  00  00 162                        000 000H
PTD  CI NHHN     202301251001               95eS 2 -07          02      00 162                        000 000H
24396CE VHNZ eP 2202301251000 5837  04 02   00      00          00  00  00 167                        000 000H
24396CE NHNN     202301251001              123eS 2  23          02      00 167                        000 000H
LAT  CI VHHZ iPD1202301251000 5857 -04 02   00      00          00  00  00 189                        000 000H
LAT  CI NHHN     202301251001              169iS 1  11          02      00 189                        000 000H
5081 NP VEHZ iPD1202301251000 5923 -16 02   00      00          00  00  00 241                        000 000H
5081 NP NHNN     202301251001              264eS 2 -08          02      00 241                        000 000H
24014CE VHNZ iPD1202301251000 5963  12 02   00      00          00  00  00 244                        000 000H
24014CE NHNN     202301251001              365eS 2  69          02      00 244                        000 000H
24048CE VHNZ iPD1202301251001   02  28 02   00      00          00  00  00 260                        000 000H
24048CE NHNN     202301251001              426iS 1  93          02      00 260                        000 000H
PDR  CI VHHZ iPD0202301251000 5994 -03 02   00      00          00  00  00 261                        000 000
PDR  CI EHHE     202301251001              422eS 2  38          02      00 261                        000 000H
```

SNCL* info

Pick time (UTC)

Phase pick info

- type P or S
- quality 0-3 (each w/ error bound, 0=best)
- impulsive/emergent usually automatic
  - Q 0-1 gets i, Q 2-3 gets e
- for Q 0-1 P picks, also 1st motion
  - U (up) or D (down)

SNCL*= Station Network Channel Location

Details | Phases | Magnitudes

Download

Download phases in csv format

Sorted by distance to nearest station

preferred origin: **phases** (ComCat view)

https://earthquake.usgs.gov/earthquakes/eventpage/ci40161279/origin/phase

Downloads

Earthquake XML (Quakeml)

- XML 2.7 MB

Phase Arrival Times

Channel	Distance	Azimuth	Phase	Arrival Time	Status	Residual	Weight
CI PTD HHZ	0.15 °	324.60 °	P	3.5 s	manual	-0.20	0.16
CI PTD HHN	0.15 °	324.60 °	S	6.3 s	manual	-0.07	0.05
CE 24396 HNZ	0.15 °	327.50 °	P	3.7 s	manual	0.04	0.11
CE 24396 HNN	0.15 °	327.50 °	S	6.6 s	manual	0.23	0.05
CI LAT HHZ	0.17 °	339.50 °	P	3.9 s	manual	-0.04	0.16
CI LAT HHN	0.17 °	339.50 °	S	7.0 s	manual	0.11	0.08
NP 5081 EHZ	0.22 °	23.70 °	P	4.6 s	manual	-0.16	0.16
NP 5081 HNN	0.22 °	23.70 °	S	8.0 s	manual	-0.08	0.05
CE 24014 HNZ	0.22 °	43.30 °	P	5.0 s	manual	0.12	0.16
CE 24014 HNN	0.22 °	43.30 °	S	9.0 s	manual	0.69	0.04
CE 24048 HNZ	0.23 °	52.00 °	P	5.3 s	manual	0.29	0.16
CE 24048 HNN	0.23 °	52.00 °	S	9.6 s	manual	0.93	0.03
CI PDR HHZ	0.24 °	70.60 °	P	5.3 s	automatic	-0.03	0.21
CI PDR HHE	0.24 °	70.60 °	S	9.5 s	manual	0.38	0.05
NP 5499 HNZ	0.24 °	76.70 °	P	5.4 s	manual	0.06	0.16
NP 5499 HNN	0.24 °	76.70 °	S	9.8 s	manual	0.59	0.04
CI SMF2 HHZ	0.25 °	57.30 °	P	5.7 s	manual	-0.07	0.16
CI SMF2 HHN	0.25 °	57.30 °	S	10.1 s	manual	0.24	0.05

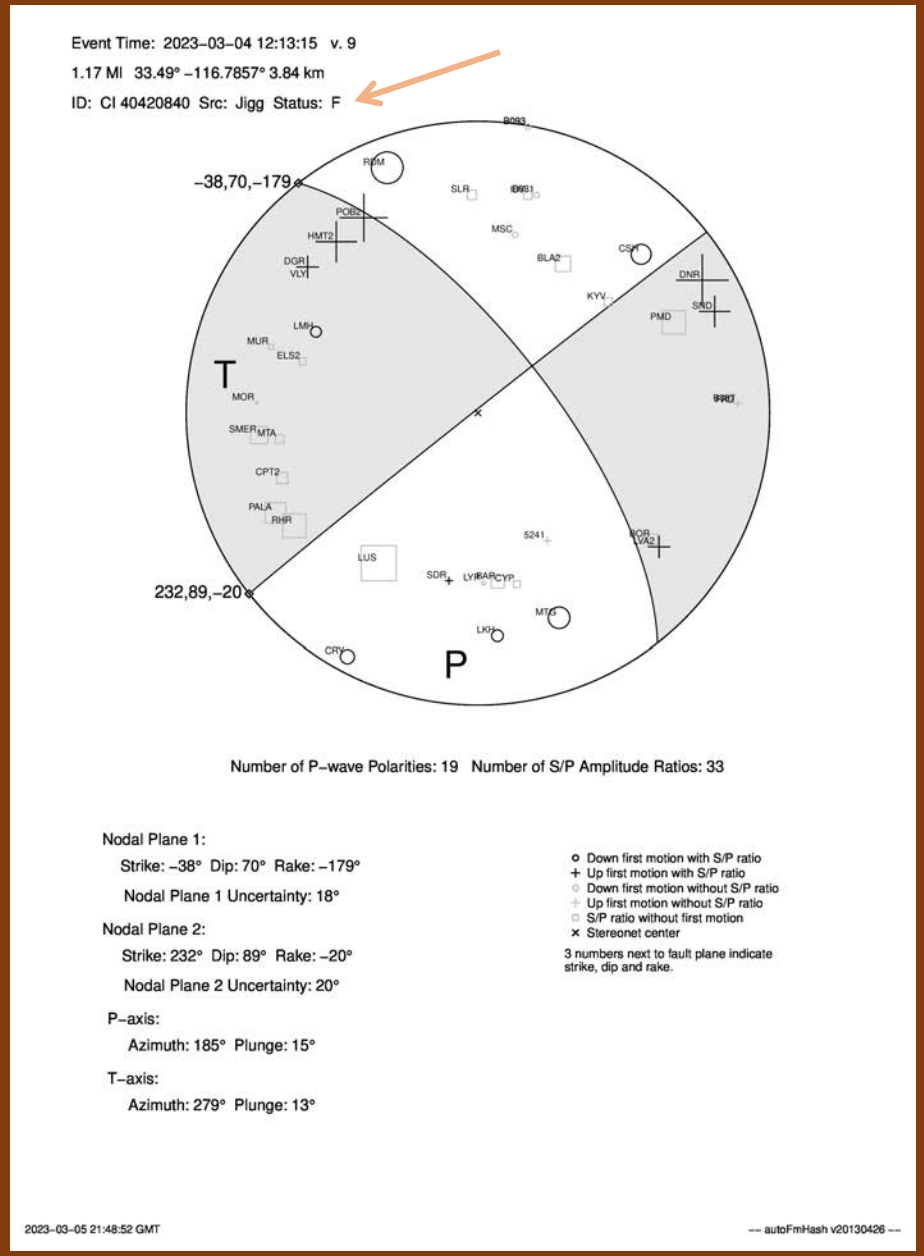
Focal Mechanisms

https://service.scedc.caltech.edu/eq-catalogs/FMsearch.php

EVID	#YYY/MM/DD HH:mm:SS.ss	ET	GT	MAG	M	LAT	LON	DEPTH	Q	NPH	WRMS	ERHOR	ERDEP	ERTIME	STRIKE	DIP	RAKE	FPUC	APUC	NPPL	MFRAC	FMQ	PROB	STDR	NSPR	MAVG
40411064	2023/02/05 00:23:12.16	eq	l	2.17	l	34.438	-119.191	12.4	A	108	0.290	0.250	0.530	0.000	352	27	61	36	38	10	11	C	68	35	32	127
40411192	2023/02/05 06:59:55.59	eq	l	2.08	l	32.334	-115.348	15.9	A	34	0.270	0.580	1.280	0.000	345	43	-144	40	41	8	22	D	39	28	8	139
40411216	2023/02/05 09:25:44.97	eq	l	2.01	l	33.673	-116.720	15.8	A	189	0.180	0.110	0.220	0.000	326	37	-176	8	8	39	3	A	100	48	57	80
40411320	2023/02/05 14:22:14.64	eq	l	2.20	l	35.551	-117.315	8.5	A	53	0.130	0.180	0.380	0.000	160	87	-163	16	20	8	0	A	83	23	23	153
40411400	2023/02/05 22:33:59.93	eq	l	2.09	l	35.664	-117.565	6.9	A	63	0.120	0.150	0.390	0.000	310	86	176	28	33	13	5	B	69	23	21	145
40411504	2023/02/06 03:44:33.38	eq	l	2.23	l	35.501	-118.396	6.5	A	70	0.140	0.130	0.700	0.000	321	67	-136	32	28	12	5	B	72	17	20	145
40412080	2023/02/08 01:21:26.67	eq	l	2.04	l	33.212	-116.061	9.7	A	122	0.210	0.150	0.490	0.000	46	24	83	43	37	14	27	C	64	28	35	129
40412288	2023/02/08 18:58:08.26	eq	l	2.03	l	35.262	-119.067	19.2	A	87	0.210	0.200	0.530	0.000	120	82	-176	25	22	15	7	A	89	45	30	74
40412640	2023/02/09 10:52:51.83	eq	l	2.50	l	35.678	-117.553	7.4	A	64	0.120	0.140	0.620	0.000	336	74	169	24	13	22	3	A	94	23	28	133
40413576	2023/02/11 19:45:40.61	eq	l	2.50	l	32.889	-116.238	5.6	A	133	0.210	0.150	0.610	0.000	145	81	-158	14	16	20	11	A	100	39	47	89
40413800	2023/02/12 13:31:20.04	eq	l	2.61	l	33.179	-115.612	2.3	A	80	0.230	0.240	0.250	0.000	266	16	149	28	19	20	8	A	86	63	37	61

- Available from Sep 1999 to present
- Input: First motions determined for Q 0-1 P-picks: U (up) or D (down)
- Input: S/P amplitude ratio
- Calculated for most events using HASH method (Hardebeck & Shearer, 2003, BSSA)
  - Prior to 2013, used fpfit method (Reasenberg & Oppenheimer, 1985)
- For more info, see Yang et al., BSSA, 2012: https://doi.org/10.1785/0120110311
- Quality criteria:

Quality Grade	Probability	Average Fault Plane Uncertainty	Min #Polarities
A	>0.8	<= 25°	>= 8
B	>0.6	<= 35°	>= 8
C	>0.5	<= 45°	>= 8
D	<=0.5	> 45°	>= 8
F	<=0.5	> 45°	< 8



Moment Tensors

Determines moment magnitude Mw for M3.5+ earthquakes

https://service.scedc.caltech.edu/eq-catalogs/CMTsearch.php

Available from
Sep 1999 to present

```
#
#    EventID  :   Unique numeric identifier assigned to each earthquake event cataloged at SCSN.
#    Lat      :   Latitude of the event origin.
#    Long     :   Longitude of the event origin.
#    Date/Time:   Origin time of the event in UTC.
#    Dep      :   Depth of the preferred origin.
#    MDep     :   Depth of the MT solution.
#    Mp       :   Preferred Magnitude.
#    Ty       :   Preferred magnitude type.
#    VR       :   Variance Reduction.
#    Str1     :   Strike of Nodal Plane 1.
#    Dip1     :   Dip of Nodal Plane 1.
#    Rake1    :   Rake of Nodal Plane 1.
#    Str2     :   Strike of Nodal Plane 2.
#    Dip2     :   Dip of Nodal Plane 2.
#    Rake2    :   Rake of Nodal Plane 2.
#    Mo       :   Scalar Moment.
#    DC       :   Percent double couple of the seismic moment tensor.
#    CLVD     :   Percent compensated linear vector dipole of the seismic moment tensor.
#    ISO      :   Percent isotropic of the seismic moment tensor. This is always 0 for SCSN solutions due our software configuration.
#    Solution Link: URL link to the complete MT solution. The solution page provides
#     1) Variance Reduction graph plotted against depths.
#     2) Waveforms of the stations selected for MT calculations.
#
#     Output is sorted by date/time in descending order.
#
#EventID      Lat        Lon        Date     Time   Dep  MDep   Mp Ty VR Str1 Dip1 Rake1 Str2 Dip2 Rake2       Mo  DC CLVD ISO Solution Link
40161279 33.88500 -118.70450  2023/01/25 10:00:55 14.71 11.00 4.19 w  85  292   50   86  118   41   95   2.44e+22  88  12   0   Solution
40151807 33.39750 -116.39333  2022/12/31 12:12:27  3.88  5.00 4.14 w  88  238   57   45  119   54  137   2.01e+22  45  55   0   Solution
40142983 35.50867 -118.39150  2022/12/07 14:13:23  5.07 14.00 3.56 w  72   16   75  -31  115   60 -162   2.73e+21  89  11   0   Solution
40129847 31.55717 -115.69933  2022/11/07 04:59:03  7.04  5.00 4.04 w  86   15   80  -19  109   72 -170   1.42e+22  65  35   0   Solution
```

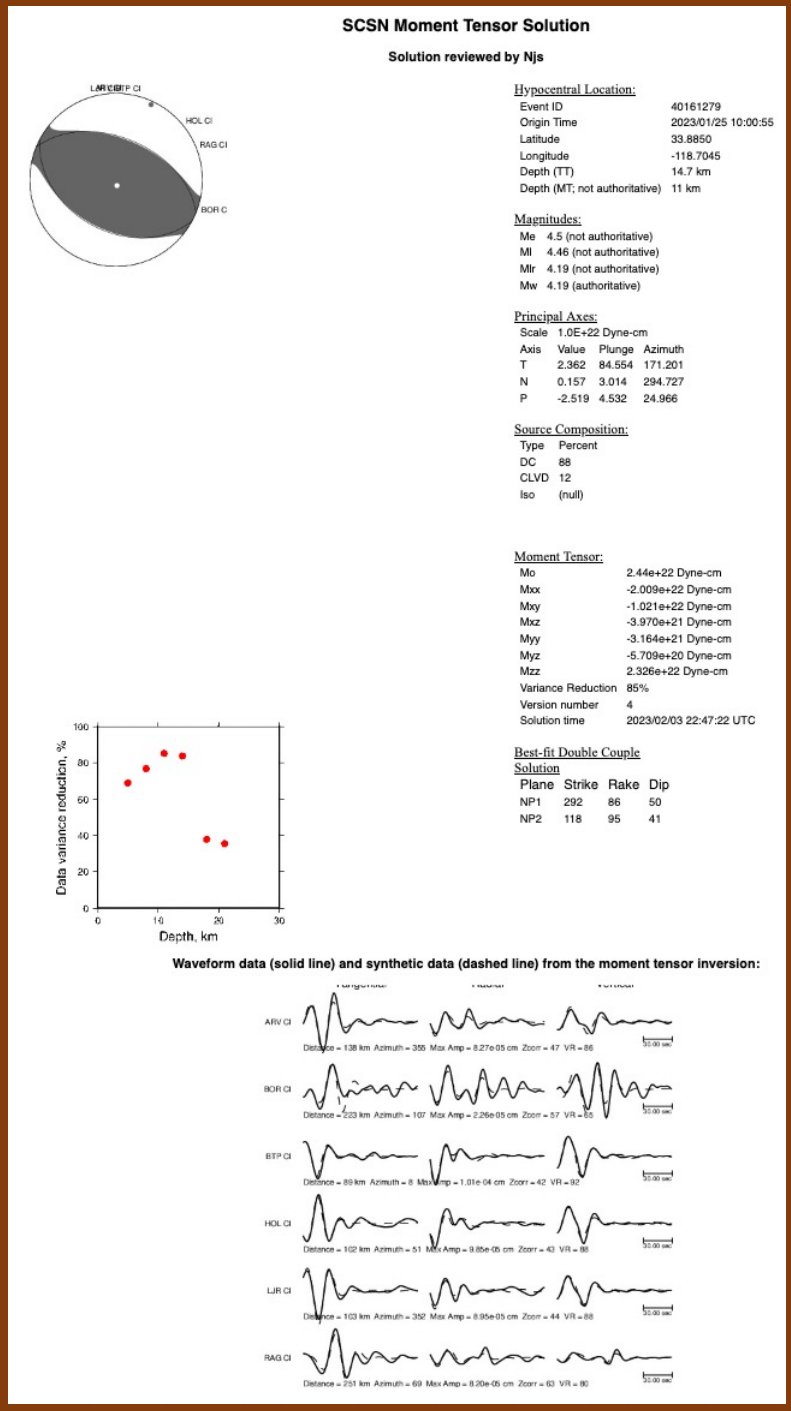
- Quality A
  - 6 stations (with azimuthal constraints)
  - Variance Reduction (VR) >=70%
  - each station has IVR >=60% AND IVR >= (VR-10%)

-> Mw, MT good enough to be immediately distributed

- Quality B
  - 4 stations (with azimuthal constraints)
  - VR >=40%
  - each station has IVR >=25% AND IVR >= (VR-15%)

-> only Mw good enough to be immediately distributed, MT needs review

- Quality C
  - 3 stations (with NO azimuthal constraints)



SCSN Moment Tensor Solution

Solution reviewed by Njs

Hypocentral Location:

Event ID	40161279
Origin Time	2023/01/25 10:00:55
Latitude	33.8850
Longitude	-118.7045
Depth (TT)	14.7 km
Depth (MT; not authoritative)	11 km

Magnitudes:

Me	4.5 (not authoritative)
Ml	4.46 (not authoritative)
Mlr	4.19 (not authoritative)
Mw	4.19 (authoritative)

Principal Axes:

Scale 1.0E+22 Dyne-cm

Axis	Value	Plunge	Azimuth
T	2.362	84.554	171.201
N	0.157	3.014	294.727
P	-2.519	4.532	24.966

Source Composition:

Type	Percent
DC	88
CLVD	12
Iso	(null)

Moment Tensor:

Mo	2.44e+22 Dyne-cm
Mxx	-2.009e+22 Dyne-cm
Mxy	-1.021e+22 Dyne-cm
Mxz	-3.970e+21 Dyne-cm
Myy	-3.164e+21 Dyne-cm
Myz	-5.709e+20 Dyne-cm
Mzz	2.326e+22 Dyne-cm
Variance Reduction	85%
Version number	4
Solution time	2023/02/03 22:47:22 UTC

Best-fit Double Couple Solution

Plane	Strike	Rake	Dip
NP1	292	86	50
NP2	118	95	41

Waveform data (solid line) and synthetic data (dashed line) from the moment tensor inversion:

Summary & Tips

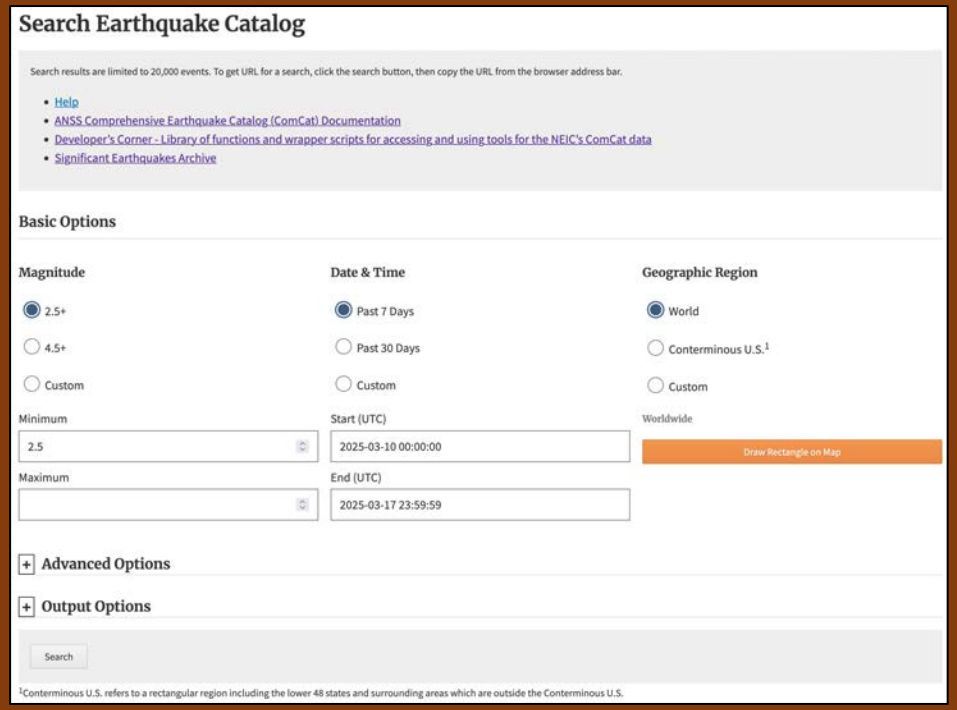
- Take the time to know and understand the data that you're using
- Official catalogs do change over time
  -> don't forget to note the date when you download data
- Networks may use different processing procedures
  - check with the specific network for details
  - especially important to consider for composite catalogs (like ComCat)
- Catalogs may have multiple origins or magnitudes for a single event
  - the one of interest to you may not be the "preferred" option from standard catalog access
- Catalog events may or may not be manually reviewed and/or adjusted
- Please cite the contributing networks & data centers of the data you use

Data Repositories & Access

Multiple Event Catalog Repository – ANSS Comprehensive Earthquake Catalog (ComCat)

https://earthquake.usgs.gov/earthquakes/search/ (web form)
https://code.usgs.gov/ghsc/esi/libcomcat-python (python api)

- All ANSS networks submit their event detections to ComCat*
- Allows for customizable searches over all ANSS RSN catalogs
  - magnitude, time, location, review status, event type, contributor/catalog, etc.
- Multiple output formats available



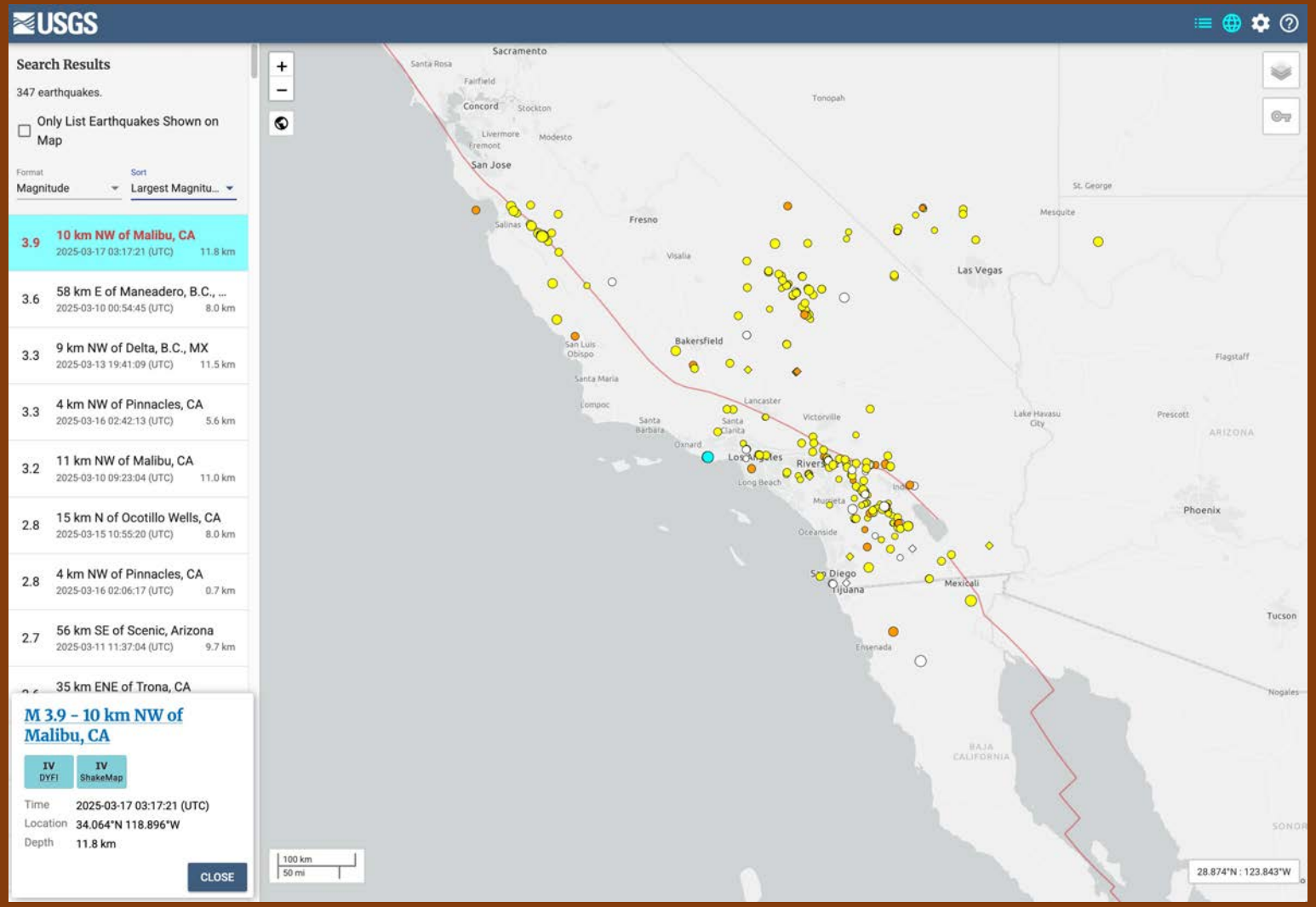
* Remember: not all RSNs use the same methods/approaches!

USGS/ComCat Data Access

"Map" output of search

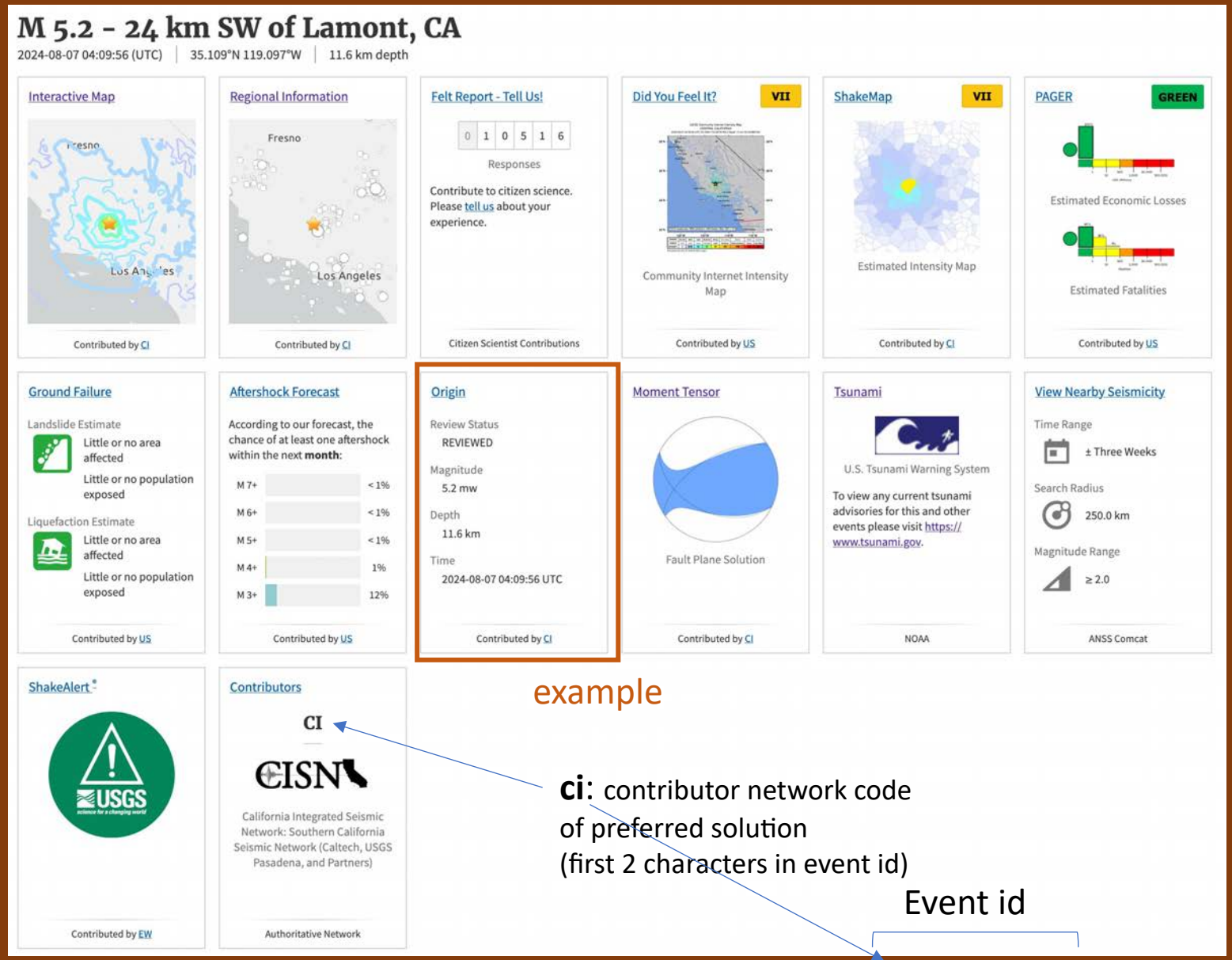
Similar to "Latest Earthquakes" map

Click on event to get more details



USGS/ComCat Event Pages

- Useful for getting detailed info about a single event
- Panels will vary based on info available
  - after event, panels updated as products added
  - smaller events have fewer products/panels
- Note data contributor at bottom of panel
  - “preferred” info shown
- Click on panel titles for more info



example

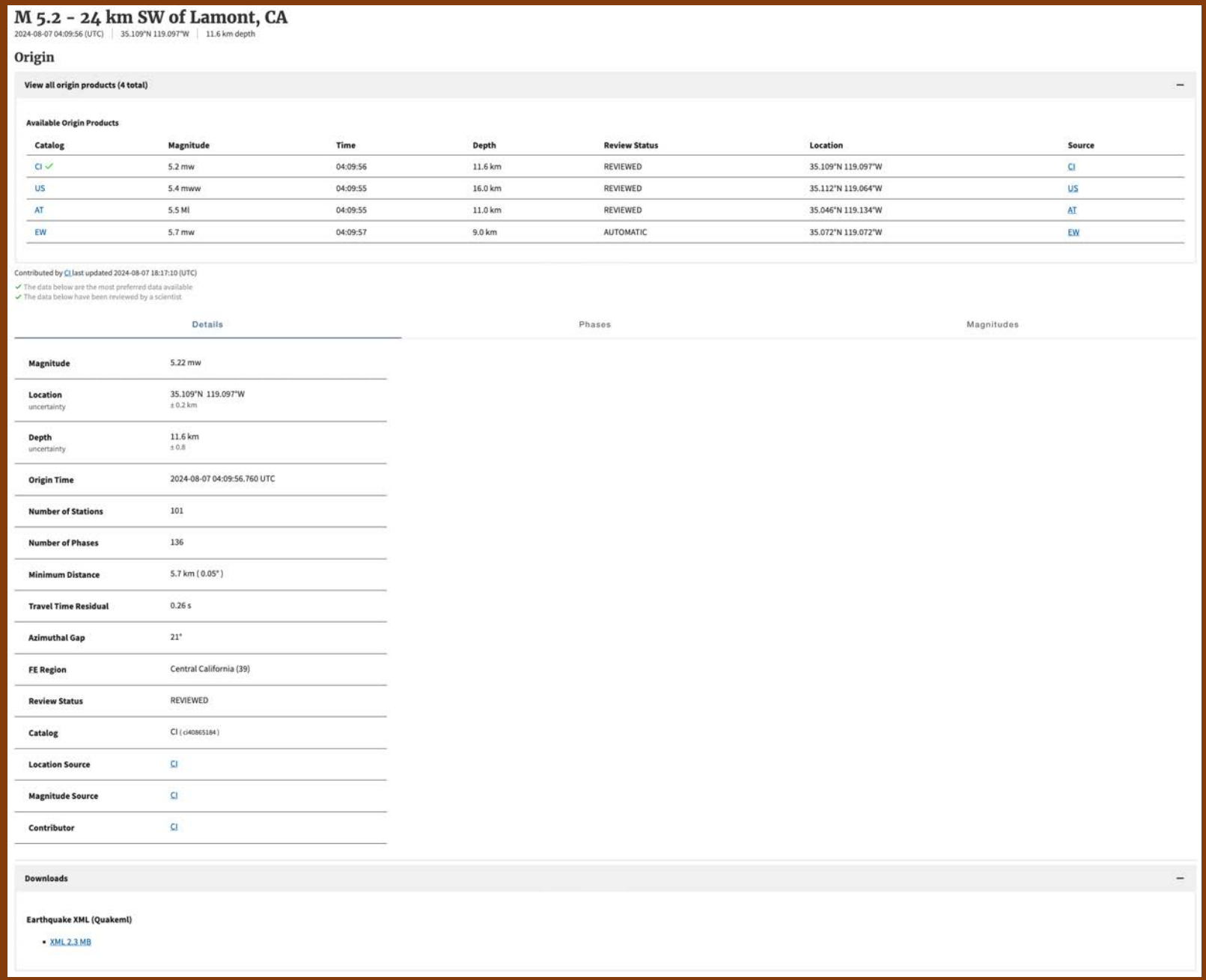
ci: contributor network code of preferred solution (first 2 characters in event id)

Event id

https://earthquake.usgs.gov/earthquakes/eventpage/ci40865184/executive

USGS/ComCat Event Pages

- Dropdown at top gives info submitted by all contributes
  - green check denotes “preferred”
  - multiple other non-preferred solutions also available
- Origin details, phase picks, and magnitude details available by clicking on lower headers
- Bottom dropdown gives files available for download



M 5.2 - 24 km SW of Lamont, CA

2024-08-07 04:09:56 (UTC) | 35.109°N 119.097°W | 11.6 km depth

Origin

View all origin products (4 total)

Available Origin Products

Catalog	Magnitude	Time	Depth	Review Status	Location	Source
CI ✓	5.2 mw	04:09:56	11.6 km	REVIEWED	35.109°N 119.097°W	CI
US	5.4 mww	04:09:55	16.0 km	REVIEWED	35.112°N 119.064°W	US
AT	5.5 Ml	04:09:55	11.0 km	REVIEWED	35.046°N 119.134°W	AT
EW	5.7 mw	04:09:57	9.0 km	AUTOMATIC	35.072°N 119.072°W	EW

Contributed by CI last updated 2024-08-07 18:17:10 (UTC)

✓ The data below are the most preferred data available

✓ The data below have been reviewed by a scientist

Details | Phases | Magnitudes

Magnitude	5.22 mw
Location uncertainty	35.109°N 119.097°W ± 0.2 km
Depth uncertainty	11.6 km ± 0.8
Origin Time	2024-08-07 04:09:56.760 UTC
Number of Stations	101
Number of Phases	136
Minimum Distance	5.7 km (0.05°)
Travel Time Residual	0.26 s
Azimuthal Gap	21°
FE Region	Central California (39)
Review Status	REVIEWED
Catalog	CI (ci40865184)
Location Source	CI
Magnitude Source	CI
Contributor	CI

Downloads

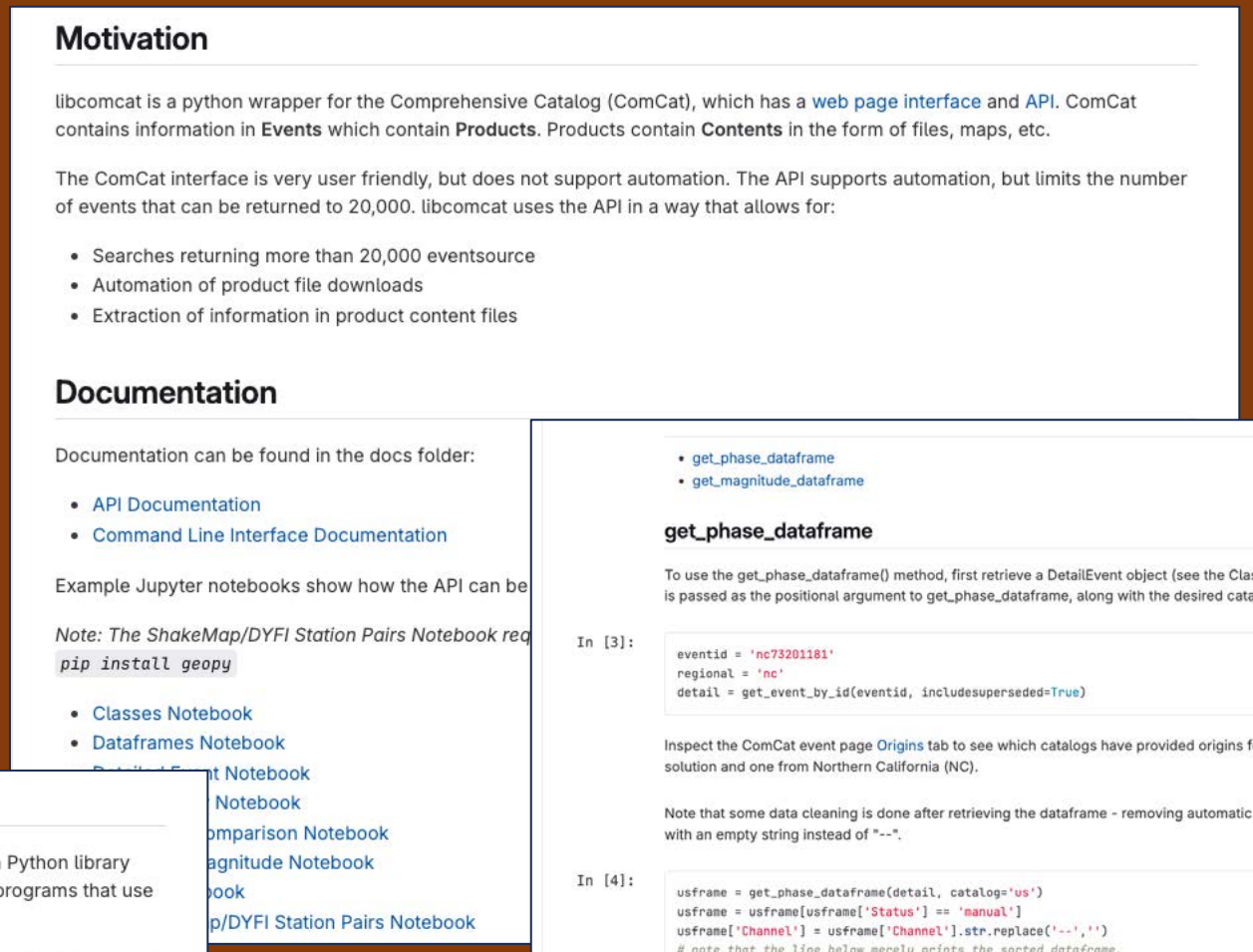
Earthquake XML (Quakeml)

- XML 2.3 MB

USGS/ComCat–
Python Library: libcomcat

https://code.usgs.gov/ghsc/esi/libcomcat-python

- python wrapper for accessing ComCat.
- Demo notebooks available
- Command line interface



Motivation

libcomcat is a python wrapper for the Comprehensive Catalog (ComCat), which has a web page interface and API. ComCat contains information in **Events** which contain **Products**. Products contain **Contents** in the form of files, maps, etc.

The ComCat interface is very user friendly, but does not support automation. The API supports automation, but limits the number of events that can be returned to 20,000. libcomcat uses the API in a way that allows for:

- Searches returning more than 20,000 eventsource
- Automation of product file downloads
- Extraction of information in product content files

Documentation

Documentation can be found in the docs folder:

- API Documentation
- Command Line Interface Documentation

Example Jupyter notebooks show how the API can be

Note: The ShakeMap/DYFI Station Pairs Notebook req
`pip install geopy`

- Classes Notebook
- Dataframes Notebook
- t Notebook
- Notebook
- mparison Notebook
- agnitude Notebook
- ook
- p/DYFI Station Pairs Notebook

- get_phase_dataframe
- get_magnitude_dataframe

get_phase_dataframe

To use the get_phase_dataframe() method, first retrieve a DetailEvent object (see the Classes notebook) a
is passed as the positional argument to get_phase_dataframe, along with the desired catalog (us, ci, etc.)

In [3]:

```
eventid = 'nc73201181'
regional = 'nc'
detail = get_event_by_id(eventid, includesuperseded=True)
```

Inspect the ComCat event page Origins tab to see which catalogs have provided origins for the event. Her
solution and one from Northern California (NC).

Note that some data cleaning is done after retrieving the dataframe - removing automatic picks and makin
with an empty string instead of "--".

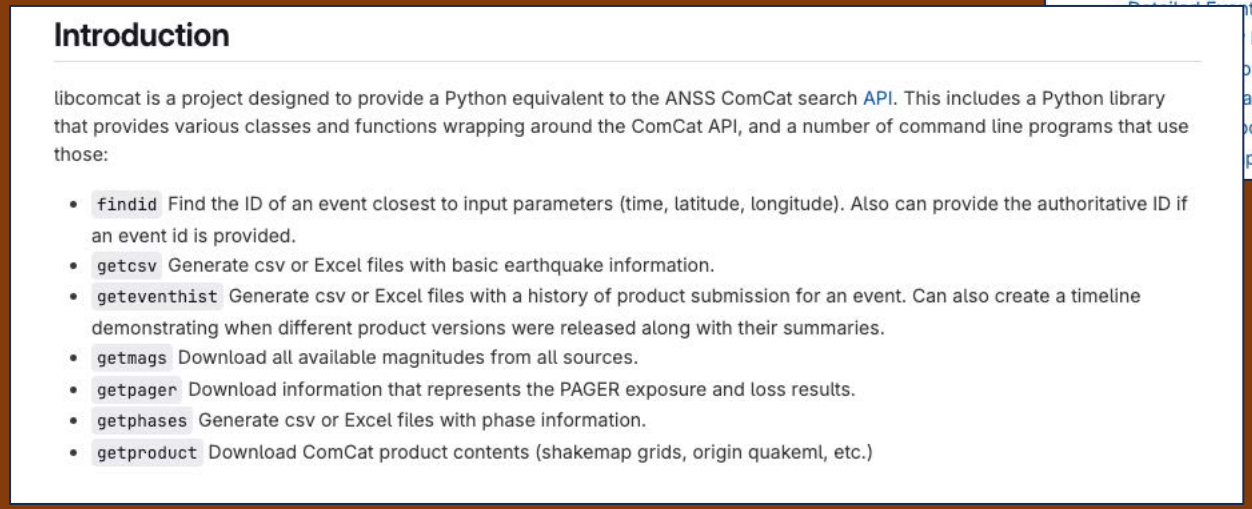
In [4]:

```
usframe = get_phase_dataframe(detail, catalog='us')
usframe = usframe[usframe['Status'] == 'manual']
usframe['Channel'] = usframe['Channel'].str.replace('--','')
# note that the line below merely prints the sorted dataframe,
# it does not modify the dataframe to be sorted by Channel.
usframe.sort_values('Channel')
```

Out [4]:

Type to search

	Channel	Distance	Azimuth	Phase	Arrival Time
145	AK.CHN.BHZ.	27.56120	313.7820	P	2019-06-23 03:58:50.960
118	AK.UNV.BHZ.	31.29330	310.0130	P	2019-06-23 03:59:25.280
146	AT.AKUT.BHZ.	30.91080	310.6970	P	2019-06-23 03:59:21.530



Introduction

libcomcat is a project designed to provide a Python equivalent to the ANSS ComCat search API. This includes a Python library that provides various classes and functions wrapping around the ComCat API, and a number of command line programs that use those:

- `findid` Find the ID of an event closest to input parameters (time, latitude, longitude). Also can provide the authoritative ID if an event id is provided.
- `getcsv` Generate csv or Excel files with basic earthquake information.
- `geteventhist` Generate csv or Excel files with a history of product submission for an event. Can also create a timeline demonstrating when different product versions were released along with their summaries.
- `getmags` Download all available magnitudes from all sources.
- `getpager` Download information that represents the PAGER exposure and loss results.
- `getphases` Generate csv or Excel files with phase information.
- `getproduct` Download ComCat product contents (shakemap grids, origin quakeml, etc.)

USGS/ComCat–
Catalog Contributors

https://earthquake.usgs.gov/data/comcat/catalog/

Catalogs

- AK - Alaska Earthquake Center
- AT - National Tsunami Warning Center
- ATLAS - ShakeMap Atlas
- AV - Alaska Volcano Observatory
- CHOY - Energy Magnitude and Broadband Depth
- CI - California Integrated Seismic Network: Southern California Seismic Network (Caltech/USGS Pasadena and Partners) and Southern California Earthquake Data Center
- DUPUTEL - Duputel et al. W phase catalog
- EQH - EQH - Coffman, von Hake and Stover, Earthquake History of the United States
- GCMT - Lamont-Doherty Earth Observatory Global CMT project, New York, USA
- HV - Hawaiian Volcano Observatory
- ISCGEM - ISC-GEM Main Catalog
- ISCGEMSUP - ISC-GEM Supplementary Catalog
- ISMPKANSAS - USGS Induced Seismicity Project (Kansas)
- LD - Lamont-Doherty Cooperative Seismographic Network

nlo Park, and Partners)

California Integrated Seismic Network: Southern California Seismic Network (Caltech/USGS Pasadena and Partners) and Southern California Earthquake Data Center

http://scedc.caltech.edu

Citation

doi:10.7909/C3WD3xH1

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Extent

1932 to present

Latitude
[31.3, 37]
Longitude
[-121, -114]
Magnitude
[-1.0, 7.5]

Contributors

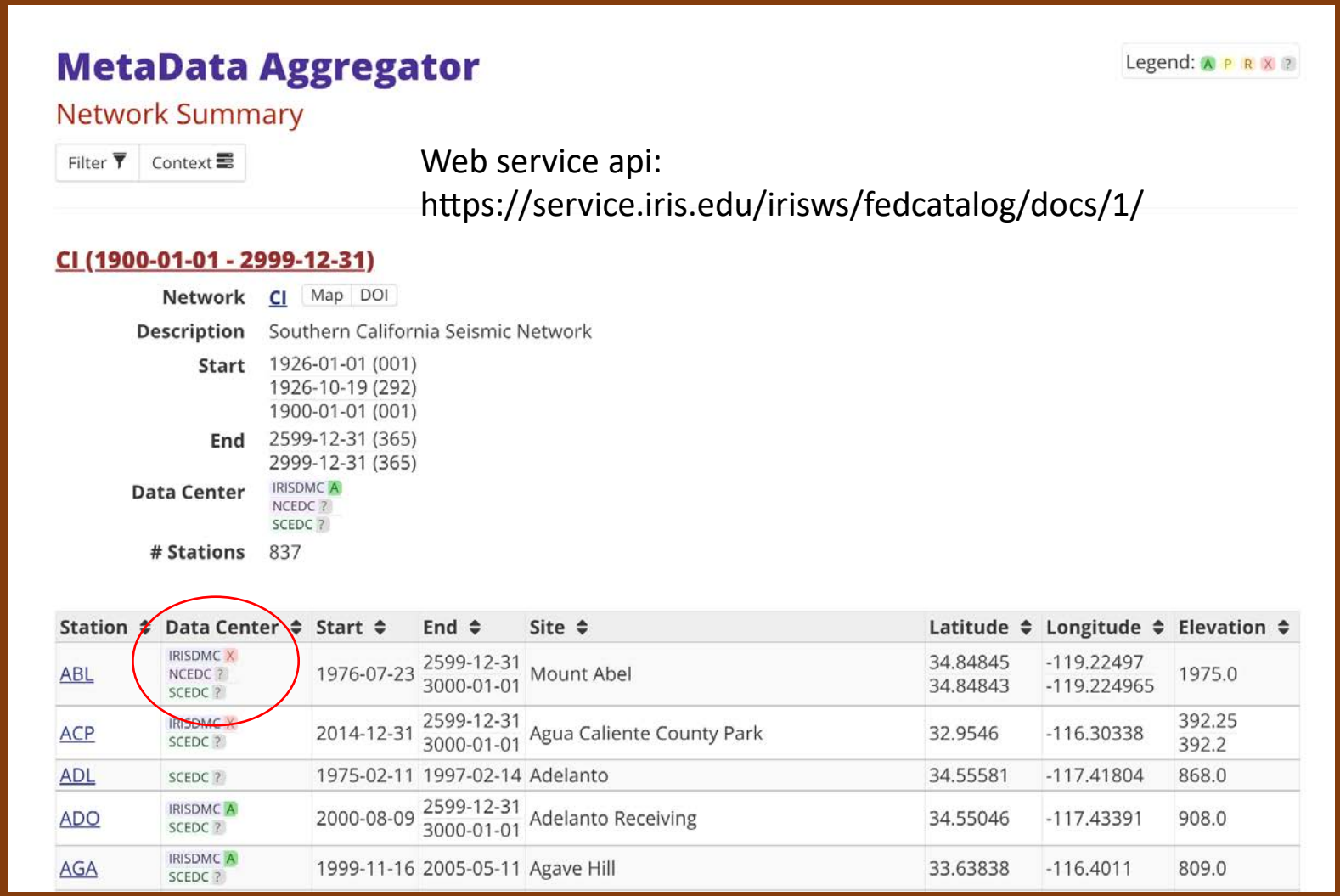
- CI (Contributor)

Multiple RSN Waveform and Metadata – NSF SAGE (Earthscope)

https://ds.iris.edu/ds/nodes/dmc/data/

- Several RSNs archive waveform and metadata at Earthscope (formerly IRIS).
- Notable exceptions: NCEDC, and SCEDC. SCEDC sends a subset to Earthscope.

Takeaway – do your due diligence. Make sure you understand the availability of the network data in your project.



MetaData Aggregator

Legend: A P R X ?

Network Summary

Filter | Context

Web service api:
https://service.iris.edu/irisws/fedcatalog/docs/1/

CI (1900-01-01 - 2999-12-31)

Network	CI Map DOI
Description	Southern California Seismic Network
Start	1926-01-01 (001) 1926-10-19 (292) 1900-01-01 (001)
End	2599-12-31 (365) 2999-12-31 (365)
Data Center	IRISDMC A NCEDC ? SCEDC ?
# Stations	837

Station	Data Center	Start	End	Site	Latitude	Longitude	Elevation
ABL	IRISDMC X NCEDC ? SCEDC ?	1976-07-23	2599-12-31 3000-01-01	Mount Abel	34.84845 34.84843	-119.22497 -119.224965	1975.0
ACP	IRISDMC X SCEDC ?	2014-12-31	2599-12-31 3000-01-01	Agua Caliente County Park	32.9546	-116.30338	392.25 392.2
ADL	SCEDC ?	1975-02-11	1997-02-14	Adelanto	34.55581	-117.41804	868.0
ADO	IRISDMC A SCEDC ?	2000-08-09	2599-12-31 3000-01-01	Adelanto Receiving	34.55046	-117.43391	908.0
AGA	IRISDMC A SCEDC ?	1999-11-16	2005-05-11	Agave Hill	33.63838	-116.4011	809.0

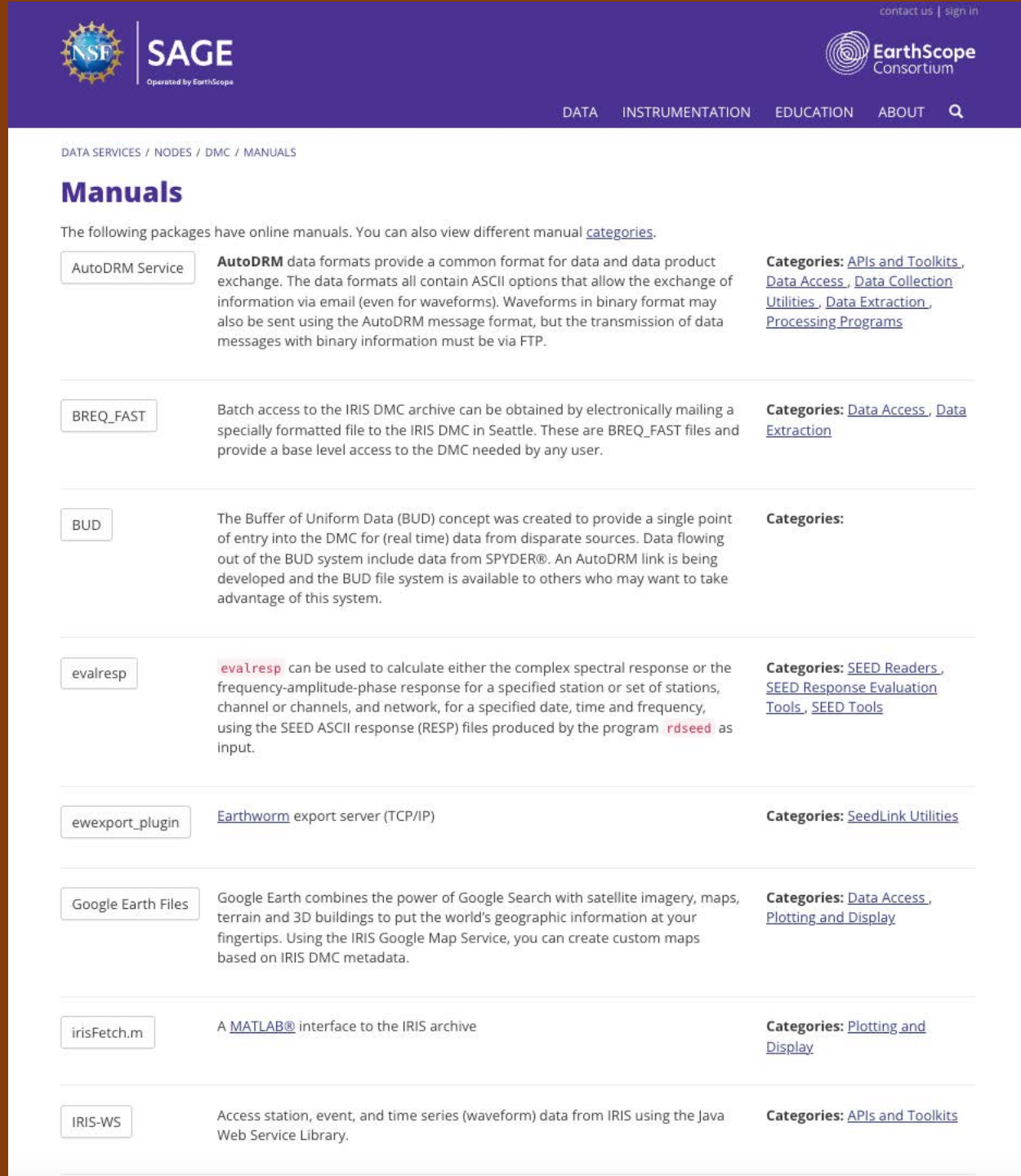
SAGE Data Access

https://ds.iris.edu/ds/nodes/dmc/data/

https://ds.iris.edu/ds/nodes/dmc/manuals/

- FDSN* webservices – standard used by many data centers.
- APIs in common programming languages. (Python, Java, Julia, Matlab, and more!)
- Software for reading common formats.
- Manuals and tutorials available.

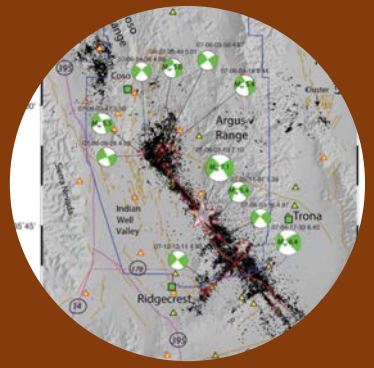
*FDSN = “International Federation of Digital Seismograph Networks”

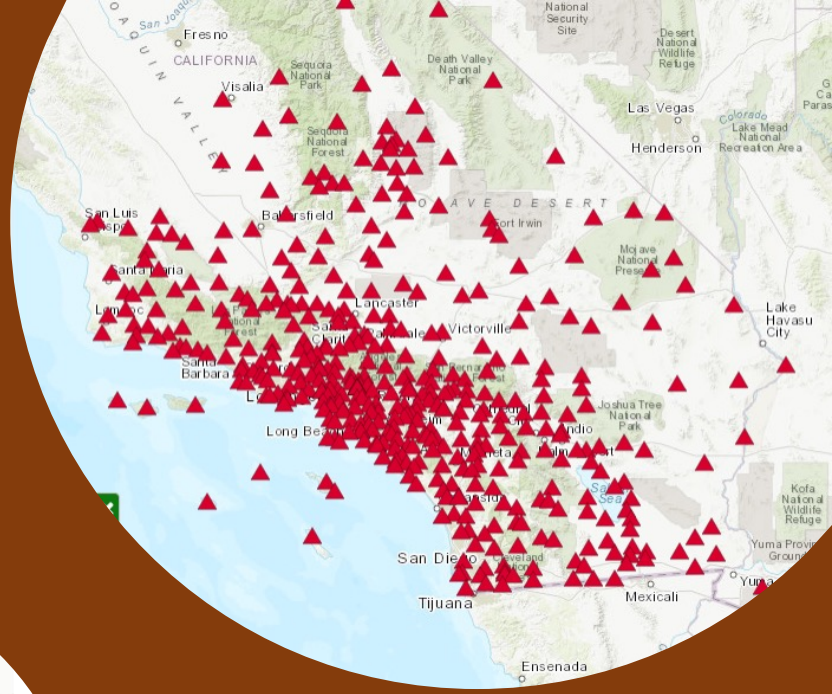


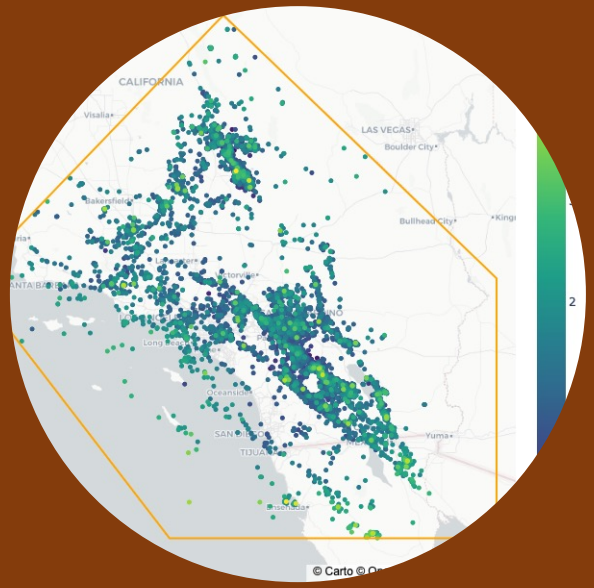
SCEDC Data Access

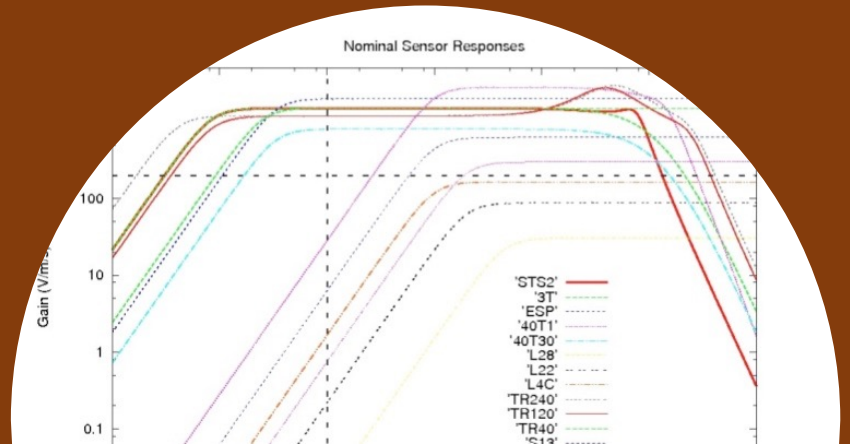
The SCEDC is the primary archive of SCSN

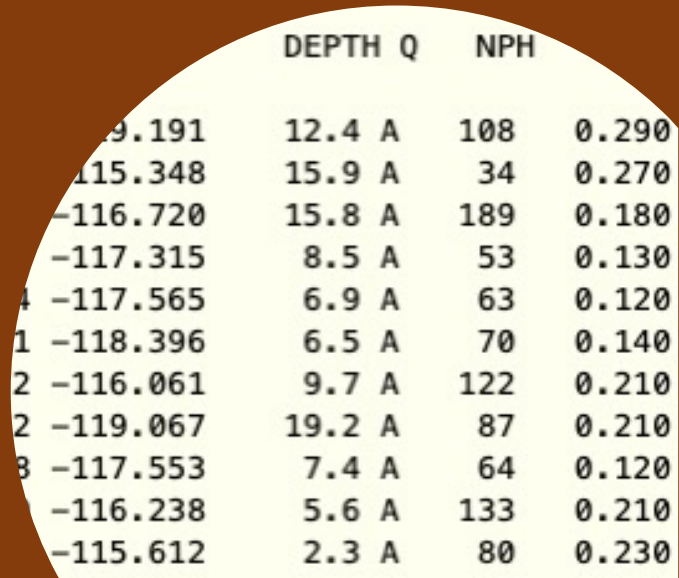
- Waveform Data – raw waveform traces – continuous and triggered (event-based)
- Station Metadata – instrument response and location of SCSN stations.
- Event Parametric Catalog – event location, arrivals etc
- Special Datasets
- User generated catalogs based on SCSN waveform data
- Additional data types for major event sequences within the SCSN region











	DEPTH	Q	NPH	
.191	12.4	A	108	0.290
115.348	15.9	A	34	0.270
-116.720	15.8	A	189	0.180
-117.315	8.5	A	53	0.130
4 -117.565	6.9	A	63	0.120
1 -118.396	6.5	A	70	0.140
2 -116.061	9.7	A	122	0.210
2 -119.067	19.2	A	87	0.210
3 -117.553	7.4	A	64	0.120
-116.238	5.6	A	133	0.210
-115.612	2.3	A	80	0.230

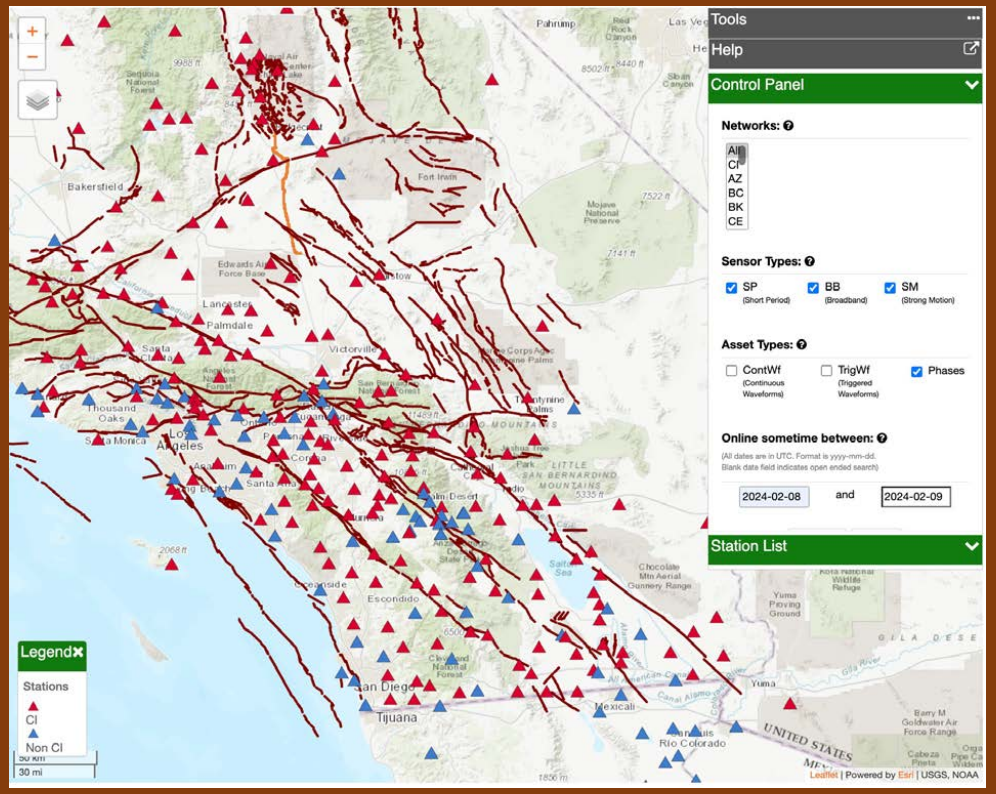
SCEDC Data Access – Methods

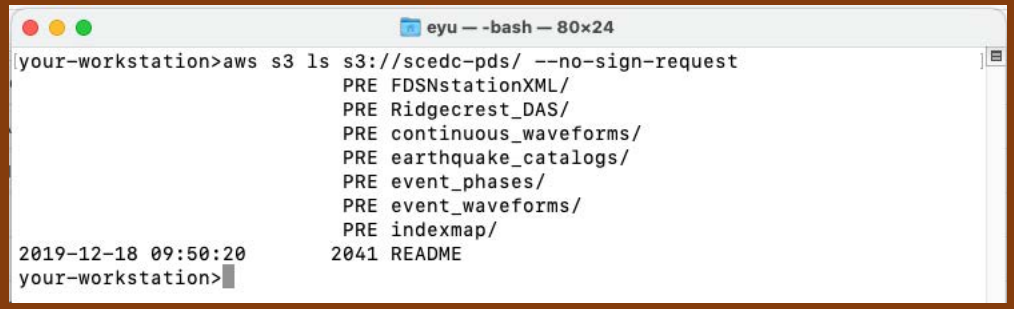
There are *many* ways to retrieve data. You can mix and match methods to suit your investigation.

- SCEDC website – best for quick look, summary level, human review, documentation, special datasets
- AWS Open Dataset – if you are looking to retrieve lots of data (fastest download speed for continuous data), please look here.
- Webservices – programmatic, FDSN standard – many libraries, multiple datacenters. Can retrieve using ObsPy scripts.
- STP – programmatic, integrated between event, waveform, metadata

SCEDC Data Access Tips

- Determine availability first, then retrieve data based on the results.
- If you are looking at catalog near Ridgecrest 2019 sequence be aware active processing is still happening.
- Consider using the AWS Open Data set.
- If looking for “integrated products”, such as event waveforms, phases or gain applied waveforms, consider using STP or PySTP
- If your area of study spans multiple seismic networks or data centers: Consider FDSN web services, or ComCat for event catalogs.
- Questions? Feedback? We are happy to help and we LOVE feedback.



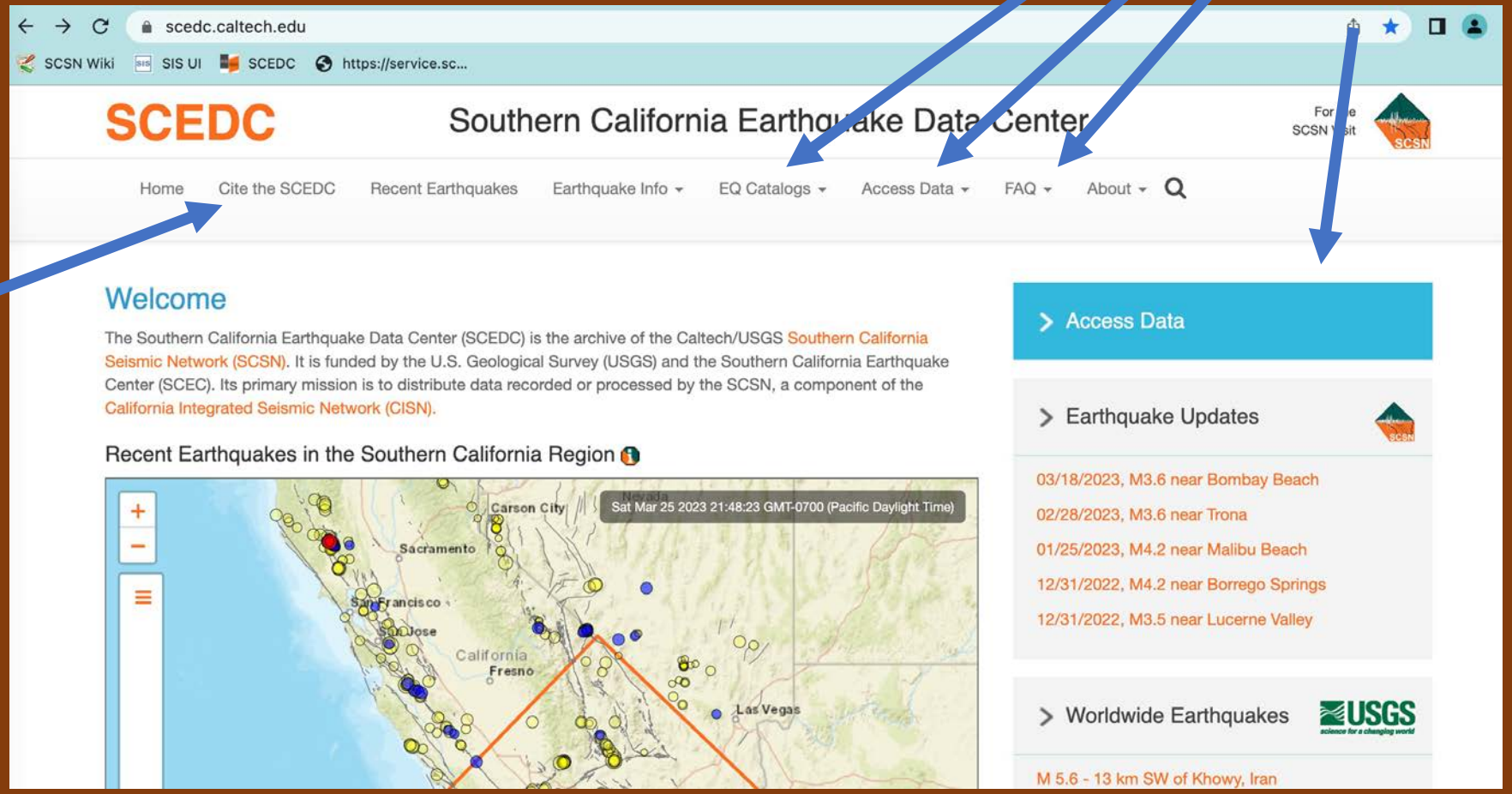


Data Access - Website

https://scedc.caltech.edu/

These are the menu links to get to the data – useful for researchers

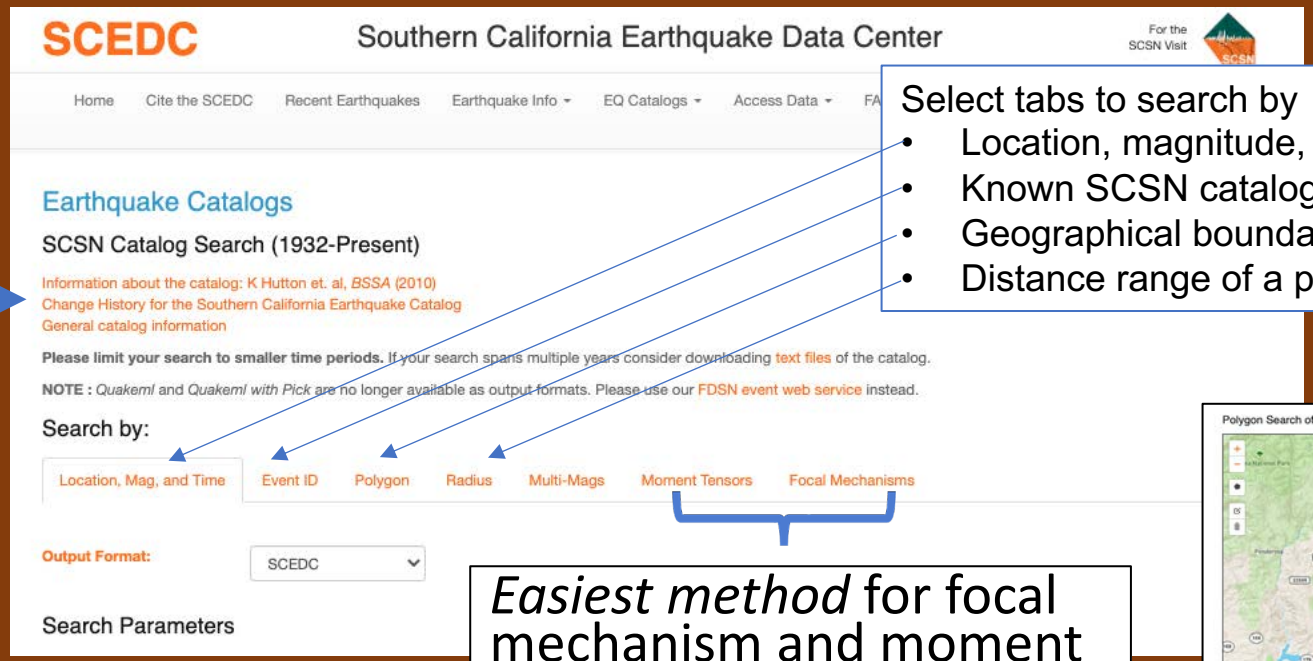
If you use any data in your published research, please cite!



Data Access – Website – EQ catalogs

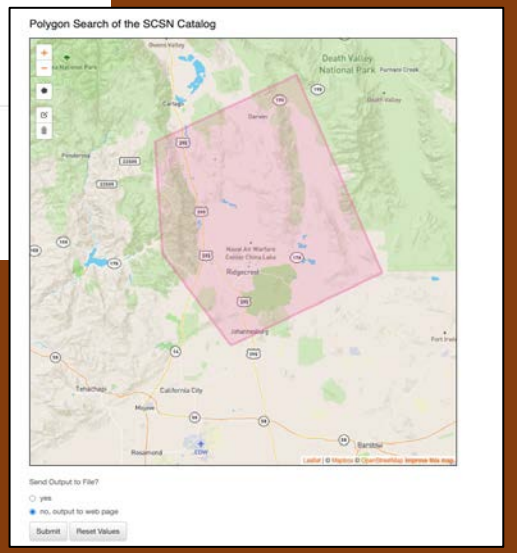
https://service.scedc.caltech.edu/eq-catalogs/date_mag_loc.php

IMPORTANT!
Documentation about the catalog itself



Select tabs to search by
- Location, magnitude, time
- Known SCSN catalog id
- Geographical boundary provided by user on map
- Distance range of a point provided by user

Easiest method for focal mechanism and moment tensor searches



Basic versioning
Year files, sent to GitHub daily
Processing status at
https://service.scedc.caltech.edu/ftp/catalogs/catalog_status/

Data Access – Website – Station Metadata

https://scedc.caltech.edu/data/station/index.html

Home | Cite the SCEDC | Recent Earthquakes | Earthquake Info | EQ Catalogs | Access Data | FAQ | About

- Web Services
- Cloud Hosted Archive
- Waveform Data
- Station Metadata and Maps
- About SCEDC Catalogs
- Special Data Sets
- Downloads
- Training and Validation Data Sets for Deep Learning

Station Metadata and Maps

The SCEDC archives and distributes station metadata for all SCSN seismic stations. For where we ha…e all stages of the instrument response so that users can derive ground motion. For the era prior to digital waveforms…res metadata from surrounding regional seismic networks, whose stations might be used in SCSN processing to he…CI metadata in our web services and station lists, but we encourage the user to go to the regional seismic network fo…is produced by the ANSS Station Information System, which is used by a number of ANSS regional seismic networks, funded by the ANSS, and maintained and developed by SCEDC staff.

Station Lists and Naming Conventions

Current lists of stations used by the SCSN, naming practices for station data, and description of how station info…

- Analog and Digital Station List - A list of any channels that exist in SCEDC archive
- Analog and Digital Station List: Vertical Components Only
- FDSN Station Web Service
- Strong-Motion Station Aliases Used Prior to 2012
- SEED Channel Descriptions
- Site Characterizations
- Overview of SCSN stations (to www.scsn.org)

Station Maps

Maps of SCSN stations

- Clickable Station Map
- Entire Array
- Entire Array - Los Angeles Region
- BH_Station Map
- BH_ Stations - Los Angeles Region

Instrumentation

Hardware and response information of SCSN stations

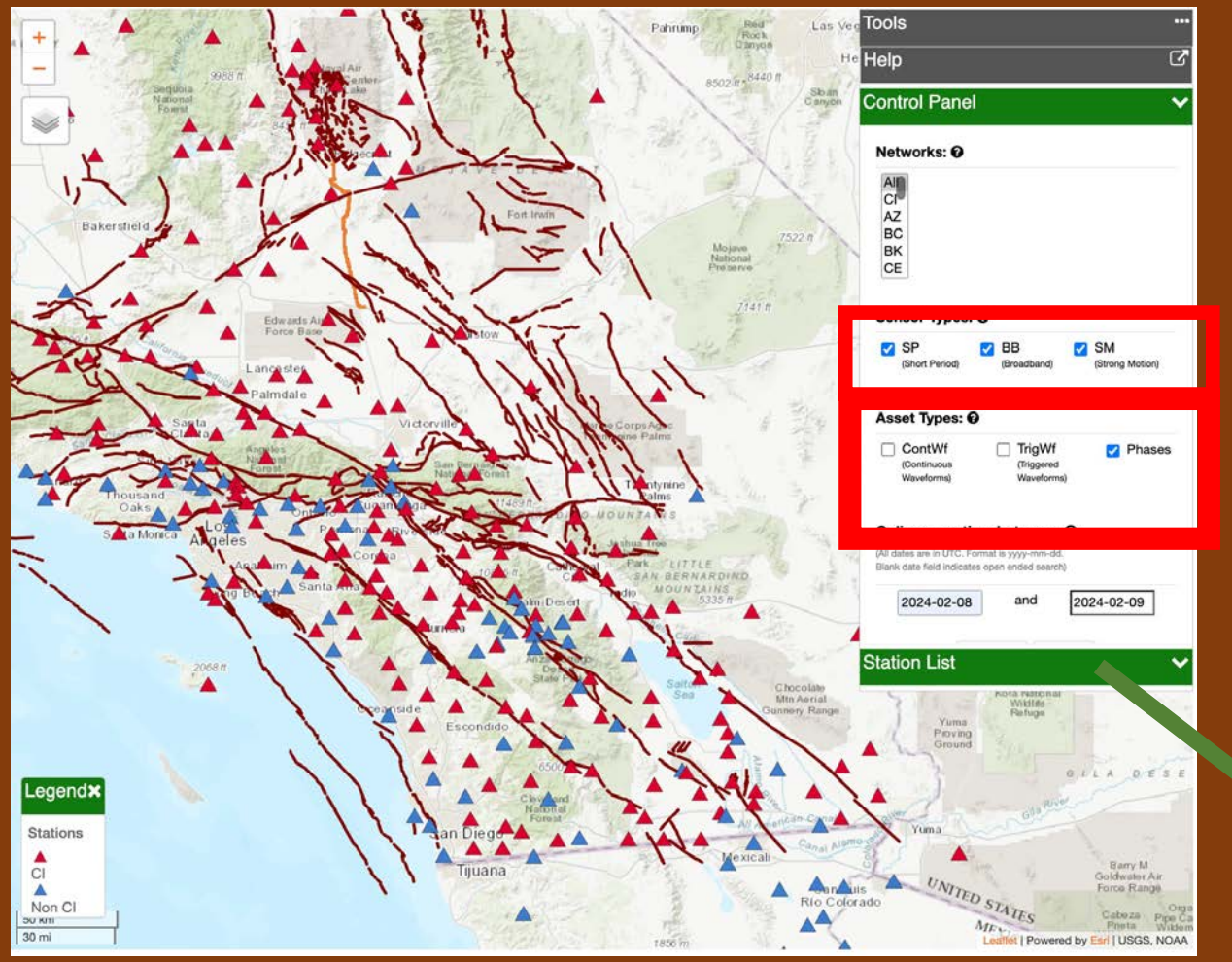
- Instrument Responses (Simple Response or "Stage 0" gain for a seismic channel)
- FDSN StationXML for SCSN Stations - A directory of files for CI stations in FDSNStationXML format. Contains stage sensitivities if available
- [1]Dataless SEED Volumes for SCSN Stations - A directory of files for CI stations in dataless SEED format. Contains stage sensitivites if available

03/21/2023 23:31:11

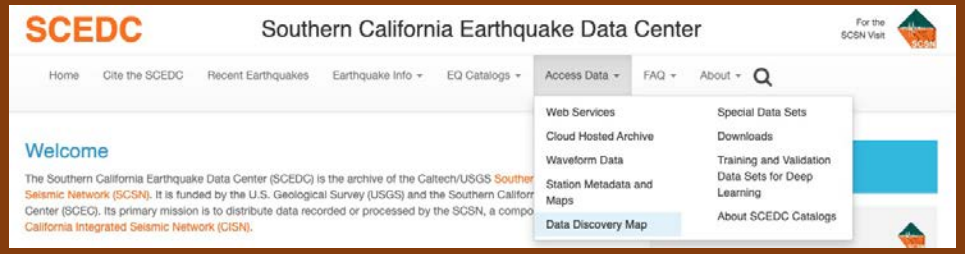
NET	STA	CHA	LOC	STANAME	LAT	LON	ELEV	ONDATE	OFFDATE	EDEPTH	REALTIME
CE	00022	HNE	--	Winterhaven - Sheriff Substati	32.73900	-114.63570	40	1999/12/01	2021/04/01	0	
CE	00022	HNN	--	Winterhaven - Sheriff Substati	32.73900	-114.63570	40	1999/12/01	2021/04/01	0	
CE	00022	HNZ	--	Winterhaven - Sheriff Substati	32.73900	-114.63570	40	1999/12/01	2021/04/01	0	
CE	01711	HNZ	--	El Centro - Imperial & Ross	32.77970	-115.56750	-7	2002/12/10	2022/03/09	0	
CE	01711	HNZ	--	El Centro - Imperial & Ross	32.77970	-115.56740	-7	2022/03/09	3000/01/01	0	
CE	01794	HNE	--	El Centro - Meloland Geotechni	32.77380	-115.44860	-4	2007/02/06	3000/01/01	0	
CE	01794	HNN	--	El Centro - Meloland Geotechni	32.77380	-115.44860	-4	2016/05/24	3000/01/01	0	
CE	01794	HNZ	--	El Centro - Meloland Geotechni	32.77380	-115.44860	-4	2016/05/24	3000/01/01	0	
CE	02140	HNE	--	El Cajon - Marshall & Vernon	32.81350	-116.97540	119	2002/11/06	3000/01/01	0	
CE	02140	HNN	--	El Cajon - Marshall & Vernon	32.81350	-116.97540	119	2002/11/06	3000/01/01	0	
CE	02140	HNZ	--	El Cajon - Marshall & Vernon	32.81350	-116.97540	119	2002/11/06	3000/01/01	0	
CE	02143	HNE	--	Santee - Mission Gorge & Cotto	32.84000	-116.97400	108	2001/08/20	2002/11/06	0	
CE	02143	HNE	--	Santee - Mission Gorge & Cotto	32.83990	-116.97410	108	2002/11/06	3000/01/01	0	
CE	02143	HNE	10	Santee - Mission Gorge & Cotto	32.83990	-116.97410	108	2017/11/15	3000/01/01	0	*realtime

NET	STA	SEED CHAN	LOC CODE	CORNER FREQ	DAMPING CONST	GAIN	GAIN UNITS	ONDATE	OFFDATE
CE	00022	HNE	--	96.4999795	0.670	2140.800	counts/(cm/sec2)	1999/12/01	2021/04/01
CE	00022	HNN	--	91.1000135	0.660	2147.510	counts/(cm/sec2)	1999/12/01	2021/04/01
CE	00022	HNZ	--	91.1999370	0.660	2140.800	counts/(cm/sec2)	1999/12/01	2021/04/01
CE	00726	HNE	--	204.0000460	0.700	4281.550	counts/(cm/sec2)	2022/03/22	3000/01/01
CE	00726	HNE	10	204.0000460	0.700	4281.550	counts/(cm/sec2)	2022/03/22	3000/01/01
CE	00726	HNN	--	221.9999568	0.700	4274.840	counts/(cm/sec2)	2022/03/22	3000/01/01
CE	00726	HNN	10	221.9999568	0.700	4274.840	counts/(cm/sec2)	2022/03/22	3000/01/01
CE	00726	HNZ	--	205.9999739	0.700	4274.840	counts/(cm/sec2)	2022/03/22	3000/01/01
CE	00726	HNZ	10	205.9999739	0.700	4274.840	counts/(cm/sec2)	2022/03/22	3000/01/01

SCEDC Data Discovery Map



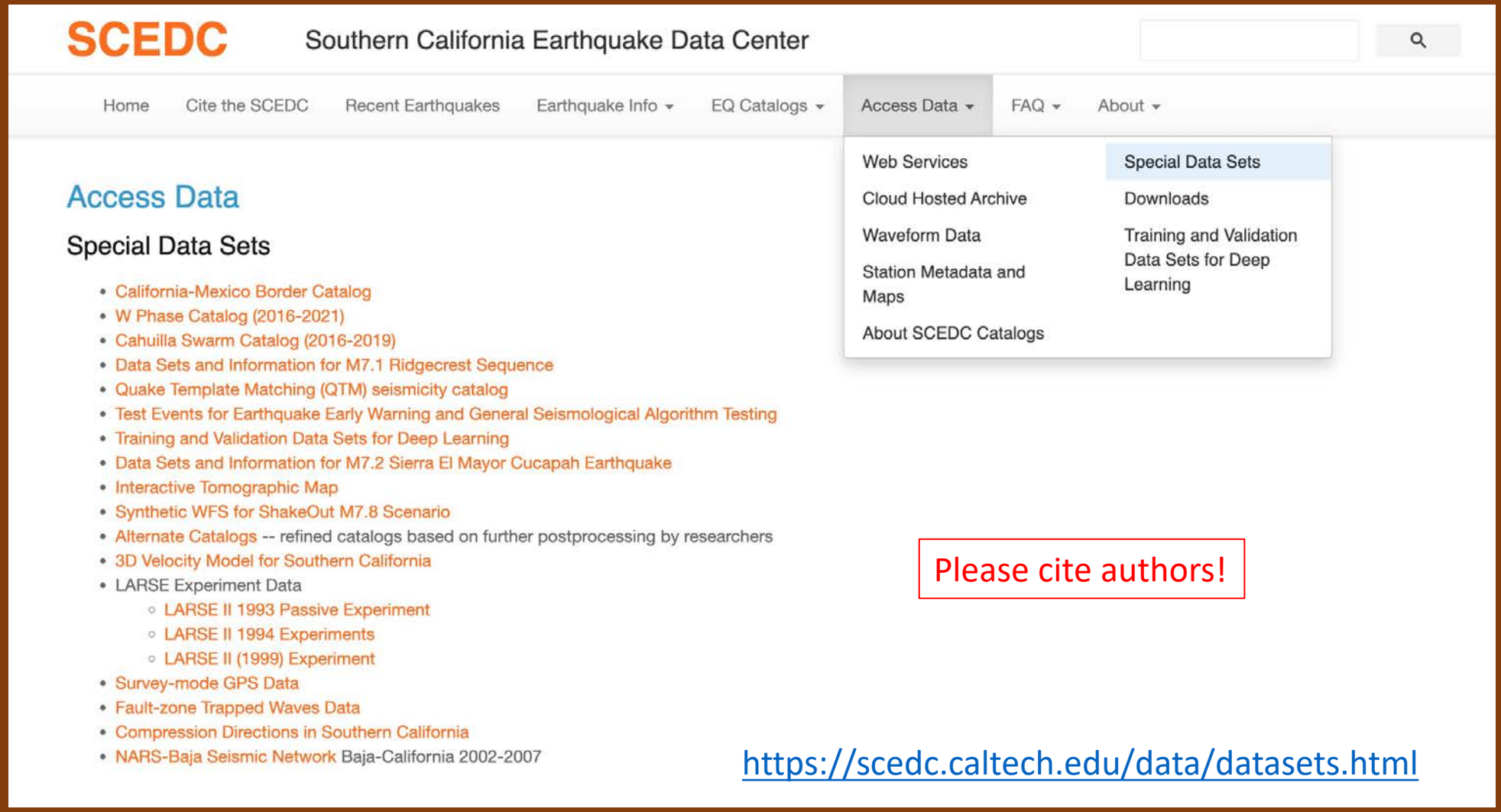
https://service.scedc.caltech.edu/SCSNStationMap/station.html



- Shows stations that have data in the SCEDC archive.
- Can filter by time, sensor type, and network code
- Can filter by if site has continuous or triggered waveforms, or if phase arrival in catalog exists.
- Can produce csv files to feed into other scripts. https://github.com/scedc/tutorials

SCEDC
Open Dataset
aws

Data Access – Website - Special Datasets



Please cite authors!

https://scedc.caltech.edu/data/datasets.html

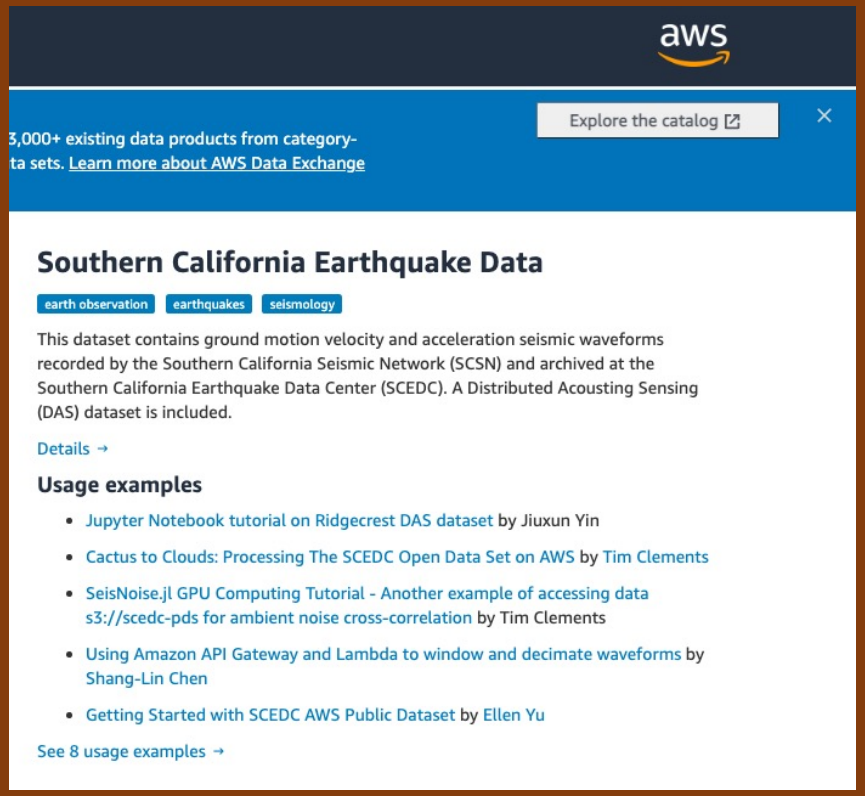
SCEDC Archive as AWS Open Dataset

Or “What if the data was already downloaded?”

AWS Open Dataset - About

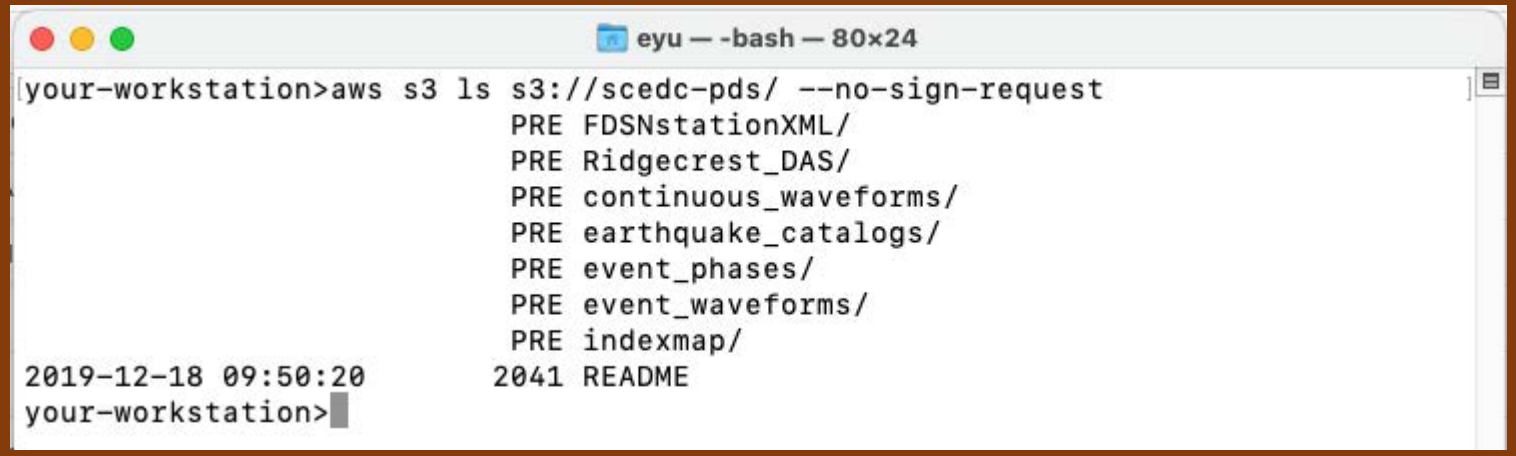
Bucket name: s3://scedc-pds
Region: us-west-2
Data Types-

- Waveforms – Cont/Trig (*mSEED*)
- Event Catalog (*ascii SCSN catalog files*)
- Phase (*ascii STP phase format*)
- Station Metadata (*ascii FDSN StationXML – only CI stations*)
- DAS (Ridgecrest array –*PASSCAL SEG-Y*)

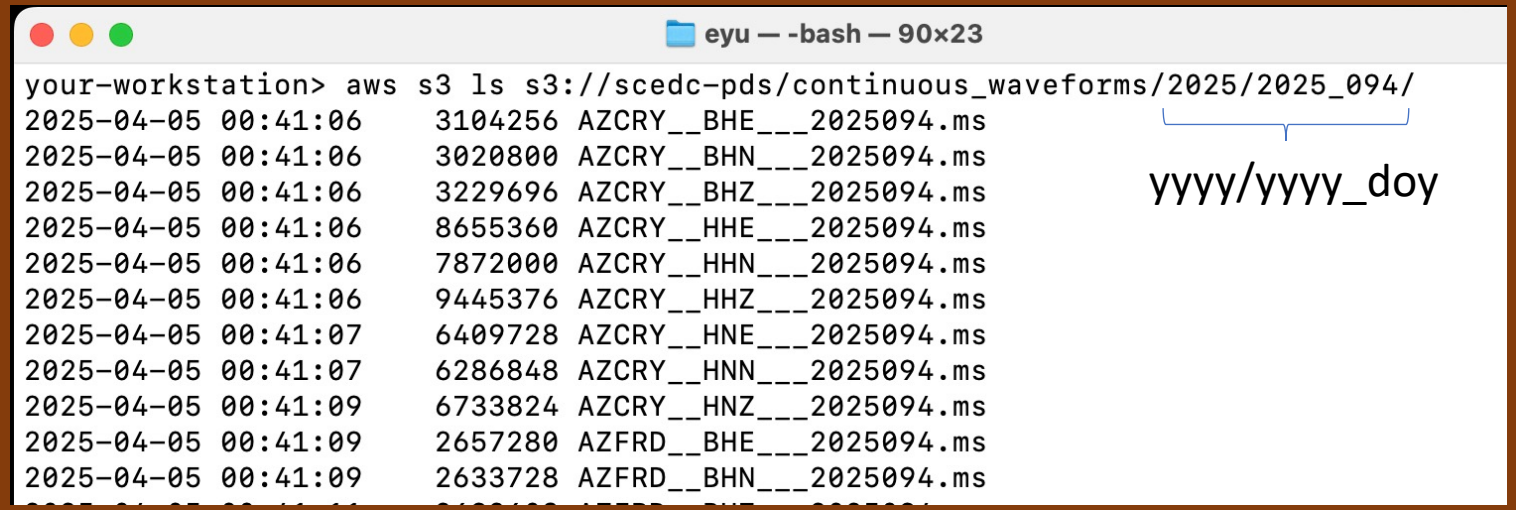


NCEDC also has one – s3://ncedc-pds

AWS Open Dataset looks very similar to file system

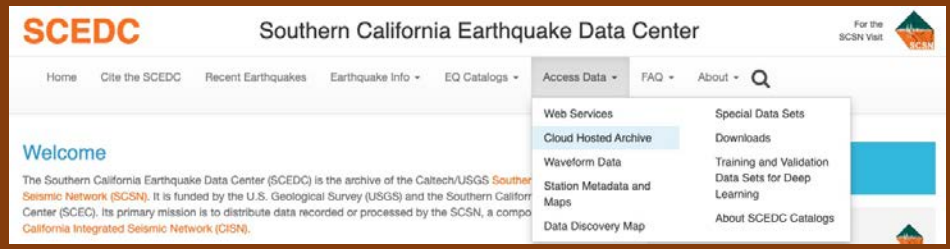


Need aws cli (cmd line interface)
or SDK in your favorite coding language
Ex Python: boto3
There are many

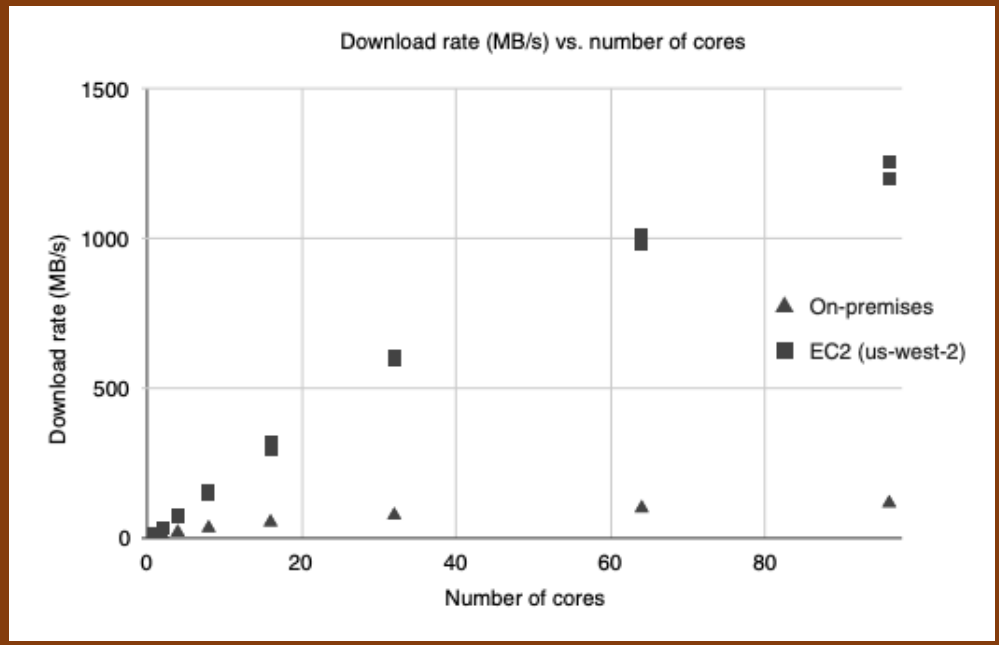


Object and prefixes have meaningful names to help search

Open Dataset



s3://scedc-pds
(no AWS account required) but you will need aws cli or sdk like boto3



Why you should use it:

- Access rates as high as 2GB/s
- 5,500 GET/HEAD requests /second/prefix
- The data is already there, why do you want to download it again?
- https://scedc.caltech.edu/data/cloud.html

Web Services at the SCEDC

SCEDC webservices are classified into FDSN and SCEDC

https://service.scedc.caltech.edu/

FDSNWS

Service interface	Version	Summary	Return options
station	v1.1	metadata for waveform time series stored	FDSN StationXML text
dataselect	v1.1	waveform time series	miniSEED
event	v1.1	event catalog webservice	QuakeML text
availability	v1.0	waveform availability webservice	text geocsv json request

SCEDCWS

Service interface	Version	Summary	Return options
webstp	v1.0	SCEDC earthquake catalog SCEDC phase data continuous waveform time series triggered waveform time series	miniSEED SAC ASCII text
sacpz	v1.0	Poles and zeros of instrument response in SAC ASCII format.	SAC
resp	v1.0		RESP

These are available for other RSNs:

EarthScope:
https://service.iris.edu/

NCEDC (Nor Cal):
https://service.ncedc.org/

FDSN Web Services

- The most common standard amongst seismic data centers
- Web form url builder: ex https://service.scedc.caltech.edu/fdsnws/dataselect/1/
- Automated or scripted requests can be made using programs such as wget or curl or libraries for HTTP access in the programming language of your choice.
- ObsPy - The ObsPy project provides a Python framework for processing seismological data. Included in this framework is the capability to retrieve data from FDSN web services. *Most Popular*
- IrisFetch.m - A MATLAB library created by IRIS that allows seamless access to data via FDSN web services. (note – deprecated, requires Matlab 2022b or older)

```
>>> from obspy.clients.fdsn.header import URL_MAPPINGS
>>> for key in sorted(URL_MAPPINGS.keys()):
...     print("{0:<11} {1}".format(key,  URL_MAPPINGS[key]))
AUSPASS     http://auspass.edu.au
BGR         http://eida.bgr.de
EIDA        http://eida-federator.ethz.ch
EMSC        http://www.seismicportal.eu
ETH         http://eida.ethz.ch
GEOFON      http://geofon.gfz-potsdam.de
GEONET      http://service.geonet.org.nz
GFZ         http://geofon.gfz-potsdam.de
ICGC        http://ws.icgc.cat
IESDMC      http://batsws.earth.sinica.edu.tw
INGV        http://webservices.ingv.it
IPGP        http://ws.ipgp.fr
IRIS        http://service.iris.edu
IRISPH5     http://service.iris.edu
ISC         http://www.isc.ac.uk
KNMI        http://rdsa.knmi.nl
KOERI       http://eida.koeri.boun.edu.tr
LMU         https://erde.geophysik.uni-muenchen.de
NCEDC       http://service.ncedc.org
NIEP        http://eida-sc3.infp.ro
NOA         http://eida.gein.noa.gr
ODC         http://www.orfeus-eu.org
ORFEUS      http://www.orfeus-eu.org
RASPISHAKE  https://data.raspberryshake.org
RESIF       http://ws.resif.fr
RESIFPH5    http://ph5ws.resif.fr
SCEDC       http://service.scedc.caltech.edu
TEXNET      http://rtserve.beg.utexas.edu
UIB-NORSAR  http://eida.geo.uib.no
USGS        http://earthquake.usgs.gov
USP         http://sismo.iag.usp.br
```

Ridgecrest 7.1 via SCEDC web services + ObsPy : https://github.com/SCEDC/tutorials

In [1]:
```
# We will use obspy for this tutorial.

from obspy import UTCDateTime
from obspy.clients.fdsn import Client
```

In [2]:
```
# Connect to the SCEDC web services.
# Use this connection for event, station and waveform web services

client = Client('SCEDC', debug=True)
```

```
Installed new opener with handlers: [<obspy.clients.fdsn.client.CustomRedirectHandler object at 0x7fd97fedc8e0>]
Base URL: http://service.scedc.caltech.edu
Request Headers: {'User-Agent': 'ObsPy/1.4.0 (Linux-4.18.0-425.3.1.el8.x86_64-x86_64-with-glibc2.28, Python 3.10.5)'}
Downloading http://service.scedc.caltech.edu/fdsnws/dataselect/1/application.wadl with requesting gzip compression
Downloading http://service.scedc.caltech.edu/fdsnws/event/1/application.wadl with requesting gzip compression
Downloading http://service.scedc.caltech.edu/fdsnws/station/1/application.wadl with requesting gzip compression
Downloading http://service.scedc.caltech.edu/fdsnws/event/1/catalogs with requesting gzip compression
Downloading http://service.scedc.caltech.edu/fdsnws/event/1/contributors with requesting gzip compression
Downloaded http://service.scedc.caltech.edu/fdsnws/dataselect/1/application.wadl with HTTP code: 200
Downloaded http://service.scedc.caltech.edu/fdsnws/station/1/application.wadl with HTTP code: 200
Downloaded http://service.scedc.caltech.edu/fdsnws/event/1/application.wadl with HTTP code: 200
Downloaded http://service.scedc.caltech.edu/fdsnws/event/1/catalogs with HTTP code: 200
Downloaded http://service.scedc.caltech.edu/fdsnws/event/1/contributors with HTTP code: 200
Discovered dataselect service
Discovered station service
Discovered event service
Storing discovered services in cache.
```

In [3]:
```
# First, retrieve event information

# set start and end times, we will use these throughout this tutorial

t1 = UTCDateTime('2019-07-04T00:00:00-07:00')
t2 = UTCDateTime('2019-07-05T20:21:00-07:00')

cat = client.get_events(starttime=t1, endtime=t2,
                        minmagnitude=7.0, catalog='SCEDC')
```

```
Downloading http://service.scedc.caltech.edu/fdsnws/event/1/query?starttime=2019-07-04T07%3A00%3A00.000000&endtime=2019-07-06T03%3A21%3A00.000000&minmagnitude=7.0&catalog=SCEDC with requesting gzip compression
Downloaded http://service.scedc.caltech.edu/fdsnws/event/1/query?starttime=2019-07-04T07%3A00%3A00.000000&endtime=2019-07-06T03%3A21%3A00.000000&minmagnitude=7.0&catalog=SCEDC with HTTP code: 200
```

In [4]:
```
# Retrieve the lat and lon for the event

print(cat)
ev_lat,ev_lon = cat[0].preferred_origin().latitude, cat[0].preferred_origin().longitude
```

```
1 Event(s) in Catalog:
2019-07-06T03:19:53.040000Z | +35.770, -117.599 | 7.1  Mw | manual
```

In [5]:
```
# Next, retrieve closest CI stations for HH[ENZ] channels associated with this event

channels='HH*'
inv = client.get_stations(network="CI", channel=channels,
                          lat=ev_lat, lon=ev_lon,
                          minradius=0, maxradius=0.2,
                          starttime=t1, endtime=t2,
                          level='channel')
print(inv)
```

```
CI.WRC2..HHN, CI.WRC2..HHE
```

In [6]:
```
# Get the list of station codes

inv_stations = inv.get_contents()['stations']

inv_closest_ci_stations = ",".join([item.split(' ')[0].split('.')[-1] for item in inv_stations])
print(inv_closest_ci_stations)
```

```
CLC,SRT,TOW2,WRC2
```

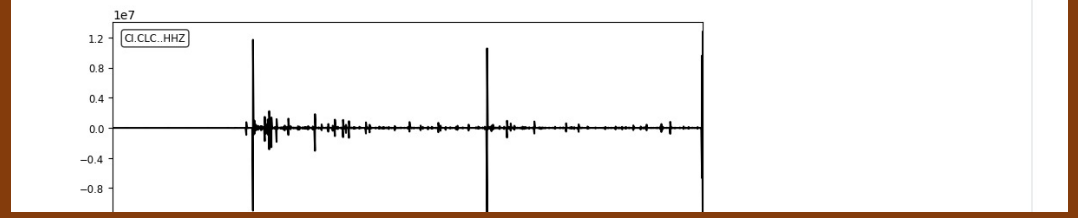
In [7]:
```
# Retrieve the waveforms for the closest CI stations

ev_waveforms = client.get_waveforms(network='CI',
                                    station=inv_closest_ci_stations,
                                    channel=channels, location='*',
                                    starttime=t1, endtime=t2)
```

```
Downloading http://service.scedc.caltech.edu/fdsnws/dataselect/1/query?starttime=2019-07-04T07%3A00%3A00.000000&endtime=2019-07-06T03%3A21%3A00.000000&network=CI&station=CLC%2CSRT%2CTOW2%2CWRC2&location=%2A&channel=HH%2A without requesting gzip compression
Downloaded http://service.scedc.caltech.edu/fdsnws/dataselect/1/query?starttime=2019-07-04T07%3A00%3A00.000000&endtime=2019-07-06T03%3A21%3A00.000000&network=CI&station=CLC%2CSRT%2CTOW2%2CWRC2&location=%2A&channel=HH%2A with HTTP code: 200
```

In [8]:
```
print(ev_waveforms)
```

```
12 Trace(s) in Stream:
CI.CLC..HHE  | 2019-07-04T06:59:59.998300Z - 2019-07-06T03:20:59.998300Z | 100.0 Hz, 15966001 samples
CI.CLC..HHN  | 2019-07-04T06:59:59.998300Z - 2019-07-06T03:20:59.998300Z | 100.0 Hz, 15966001 samples
CI.CLC..HHZ  | 2019-07-04T06:59:59.998300Z - 2019-07-06T03:20:59.998300Z | 100.0 Hz, 15966001 samples
CI.SRT..HHE  | 2019-07-04T06:59:59.998300Z - 2019-07-06T03:20:59.998300Z | 100.0 Hz, 15966001 samples
CI.SRT..HHN  | 2019-07-04T06:59:59.998300Z - 2019-07-06T03:20:59.998300Z | 100.0 Hz, 15966001 samples
CI.SRT..HHZ  | 2019-07-04T06:59:59.998300Z - 2019-07-06T03:20:59.998300Z | 100.0 Hz, 15966001 samples
CI.TOW2..HHE | 2019-07-04T06:59:59.998300Z - 2019-07-06T03:20:59.998300Z | 100.0 Hz, 15966001 samples
CI.TOW2..HHN | 2019-07-04T06:59:59.998300Z - 2019-07-06T03:20:59.998300Z | 100.0 Hz, 15966001 samples
CI.TOW2..HHZ | 2019-07-04T06:59:59.998300Z - 2019-07-06T03:20:59.998300Z | 100.0 Hz, 15966001 samples
CI.WRC2..HHE | 2019-07-04T06:59:59.998300Z - 2019-07-06T03:20:59.998300Z | 100.0 Hz, 15966001 samples
CI.WRC2..HHN | 2019-07-04T06:59:59.998300Z - 2019-07-06T03:20:59.998300Z | 100.0 Hz, 15966001 samples
CI.WRC2..HHZ | 2019-07-04T06:59:59.998300Z - 2019-07-06T03:20:59.998300Z | 100.0 Hz, 15966001 samples
```

In [9]:
```
ev_waveforms.label='Ridgecrest 7.1 earthquake, 05-July-2019'
ev_waveforms.plot(equal_scale=False)
```



Please be aware when using web services

- Please be a good digital citizen and request
  - reasonable amounts of data per request
    - Requested time windows that don't fit this formula will return no data.
      (timewindow * sr + 100) <= 400 * 1024 * 1024 / 4
      where timewindow is end-start in seconds, sr is sample rate of the channel.
  - Max 3 concurrent sessions

- Check the HTTP status code returned for your request.

- Requesting too much data may result in not receiving your full request.
- Flooding web services with requests may result in your IP’s being temporarily blacklisted.

STP (Seismogram Transfer Program)

STP Overview

- The engine behind SCEDC's on-premises data access
- C client
- STP is scriptable – put commands in a file and feed them to the client

```
cat commands.txt | stp
```

- Provides access to:
  - SCSN event catalog
  - SCSN event triggered waveforms and phase picks
  - Station metadata
  - Continuously archived waveform data

PySTP Python Module for STP

```
In [6]: waveforms = stp.get_trig(evid, net='CI', sta='BAK')
        waveforms

        Processed 9 waveform traces

Out[6]: {40161279: 9 Trace(s) in Stream:
        CI.BAK..BHE | 2023-01-25T10:00:47.169538Z - 2023-01-25T10:06:06.569538Z | 40.0 Hz, 12777 samples
        CI.BAK..BHN | 2023-01-25T10:00:49.369538Z - 2023-01-25T10:06:05.394538Z | 40.0 Hz, 12642 samples
        CI.BAK..BHZ | 2023-01-25T10:00:45.069538Z - 2023-01-25T10:06:03.969538Z | 40.0 Hz, 12757 samples
        CI.BAK..HHE | 2023-01-25T10:00:49.318393Z - 2023-01-25T10:06:03.598393Z | 100.0 Hz, 31429 samples
        CI.BAK..HHN | 2023-01-25T10:00:48.338393Z - 2023-01-25T10:06:05.348393Z | 100.0 Hz, 31702 samples
        CI.BAK..HHZ | 2023-01-25T10:00:50.318394Z - 2023-01-25T10:06:04.688394Z | 100.0 Hz, 31438 samples
        CI.BAK..HNE | 2023-01-25T10:00:46.238393Z - 2023-01-25T10:06:03.268393Z | 100.0 Hz, 31704 samples
        CI.BAK..HNN | 2023-01-25T10:00:49.238393Z - 2023-01-25T10:06:03.368393Z | 100.0 Hz, 31414 samples
        CI.BAK..HNZ | 2023-01-25T10:00:45.788393Z - 2023-01-25T10:06:07.388393Z | 100.0 Hz, 32161 samples}
```

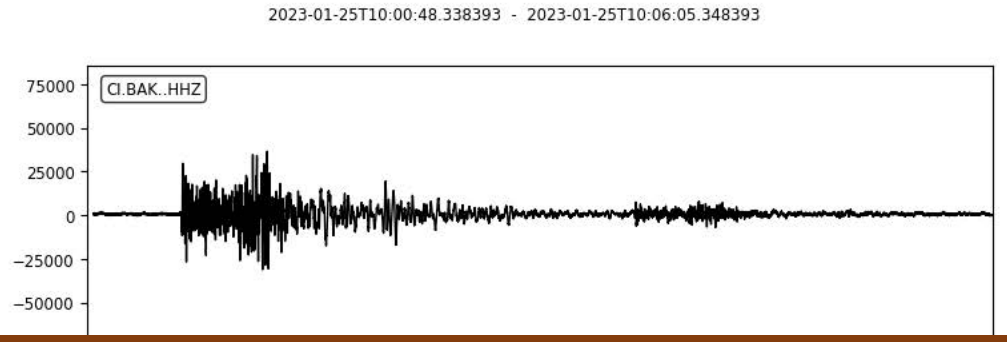
`waveforms` is a dictionary that maps the event ID to an ObsPy stream.

ObsPy stream methods can be used to select traces from the stream and to do processing and plotting. The following line returns a new Stream that only contains data from CI.BAK.HH channels.

```
In [ ]: waveforms[evid].select(network='CI', station='BAK', channel='HH*')
```

Let's use ObsPy's 'plot()' function to plot the waveforms from CI.BAK.HH.

```
In [6]: waveforms[evid].select(channel='HH*').plot()
```



https://github.com/SCEDC/tutorials

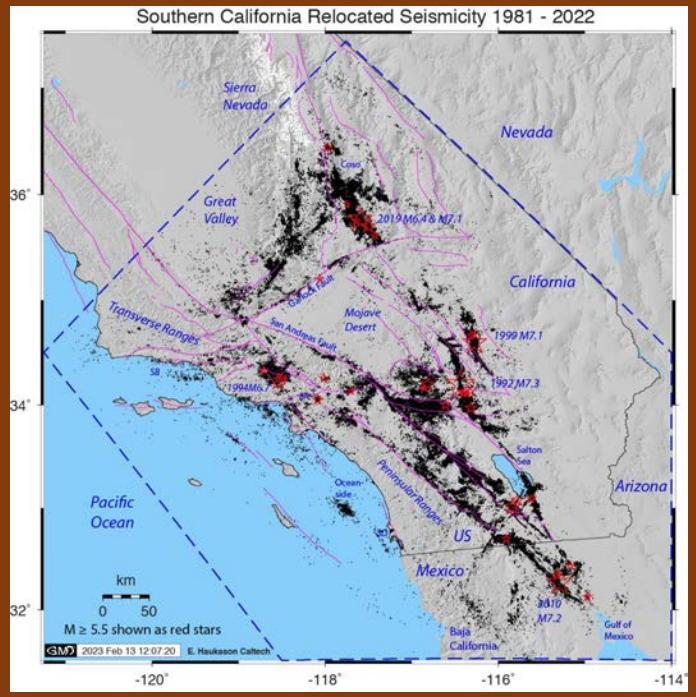
- Connects to the same STP servers as the C clients
- Reads waveforms into ObsPy Stream objects and events and phase picks into Catalog objects
- Currently supports triggered downloads, event catalogs, triggered waveform availability, and phase picks
- Don't need to know STP's query language
- Use in Python programs or Jupyter Notebooks

Data Access Tips

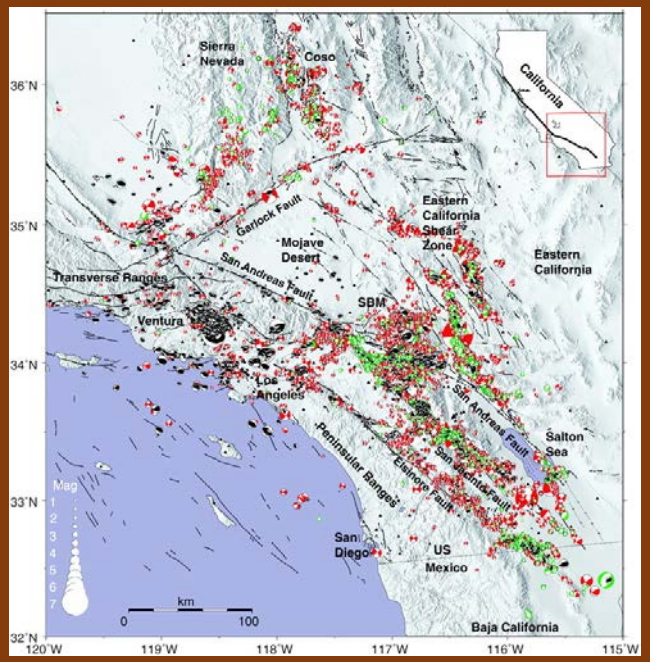
- Study availability first, then retrieve data based on the results.
- If you are looking at catalog near Ridgecrest 2019 sequence, be aware active processing is still happening.
- Consider using the AWS Open Data set, especially if your study spans months or years
- If looking for “integrated products”, such as event waveforms, phases or gain applied waveforms, consider using STP or PySTP
- If your area of study spans multiple seismic networks or data centers: Consider FDSN web services, or ComCat for event catalogs.
- If you use CI data in your research, please cite the SCSN and SCEDC (see citation slide)
  - Generalizing – please cite the network if you use their data.
- Questions? Feedback? We are happy to help and we LOVE feedback.

What Will **YOU** Do With 90+ Years of Seismic Data?

Double-difference Catalog
- updated yearly
- two formats
- available for 1981-2024
- maintained by E. Hauksson



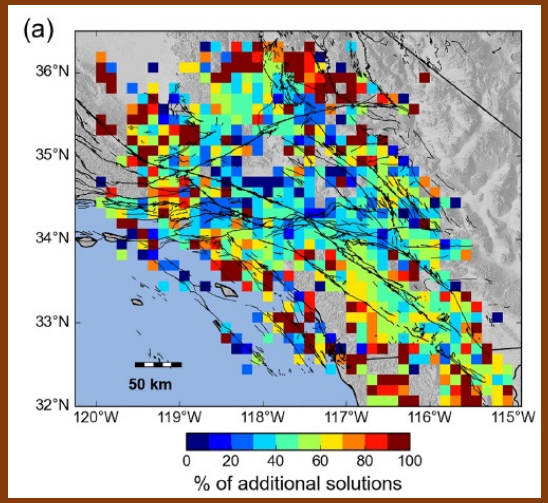
Refined FM Catalog
- updated yearly
- available for 1981-2024
- maintained by E. Hauksson



And others!

Template Matching (QTM) Catalog
- available for 2008-2017
- contains >1.8 million events
- produced by Z. Ross

Deep Learning FM Catalog
- available for 1981-2021
- uses HASH method with additional phases & polarities from DL
- produced by Y. Cheng



https://scedc.caltech.edu/eq-catalogs/altcatalogs.html

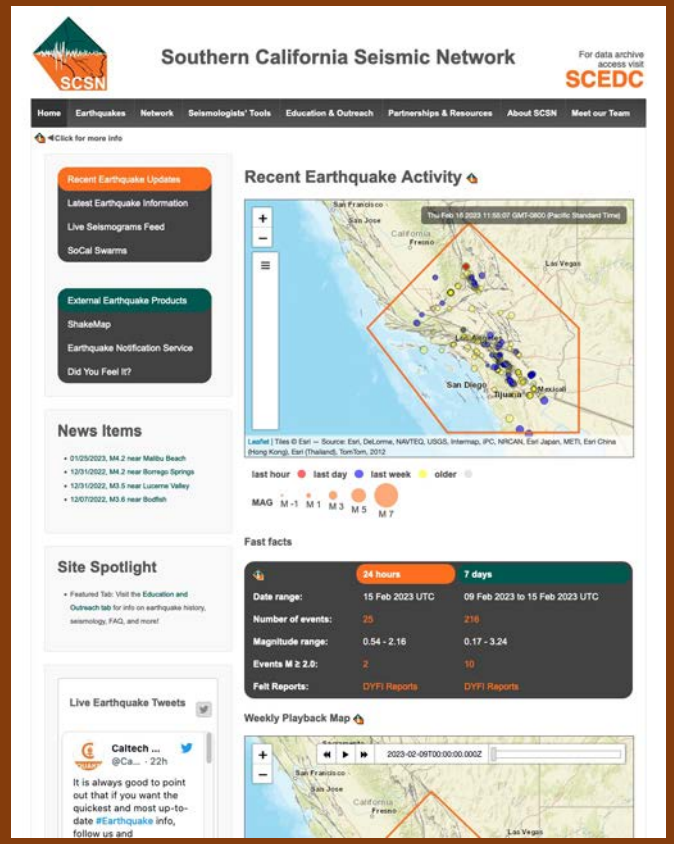
Tutorials

- available on github : https://github.com/SCEDC/tutorials
- Ridgecrest 7.1 via SCEDC web services + ObsPy
  - https://bit.ly/scedc_ws_ridgecrest7_1
- Retrieve waveform data from SCEDC PDS, leveraging the availability web service
  - https://bit.ly/scedc_pds_fetch_waveforms_parallel
- PySTP download and demos: https://github.com/SCEDC/pystp/

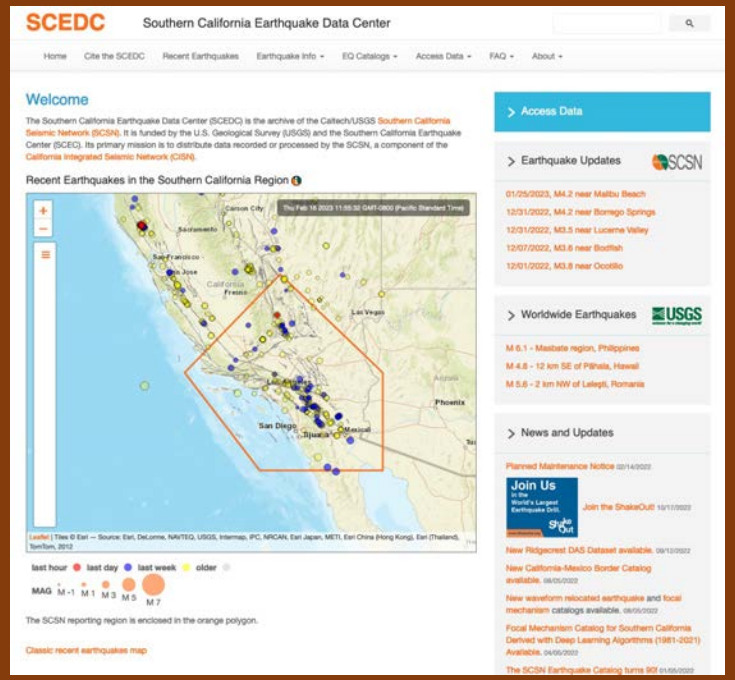
Resources

- SCEDC web services : https://service.scedc.caltech.edu/
- ObsPy : https://docs.obspy.org/
- IRIS Fetch scripts : https://seiscode.iris.washington.edu/projects/ws-fetch-scripts/wiki/Use_with_other_data_centers
- IrisFetch.m : http://ds.iris.edu/ds/nodes/dmc/software/downloads/irisFetch.m/ (note – irisFetch.m is deprecated. ☹)
- FDSN web service specification : https://www.fdsn.org/webservices/
- STP client download links and manual: https://scedc.caltech.edu/data/stp/
- SCEDC AWS Open Dataset: https://scedc.caltech.edu/data/cloud.html
- Comcat search (web form) : https://earthquake.usgs.gov/earthquakes/search/
- Comcat python api : https://code.usgs.gov/ghsc/esi/libcomcat-python
- ComCat contributor: https://earthquake.usgs.gov/data/comcat/catalog/
- Earthscope Metadata Aggregator: https://ds.iris.edu/mda/

https://www.scsn.org



https://scedc.caltech.edu

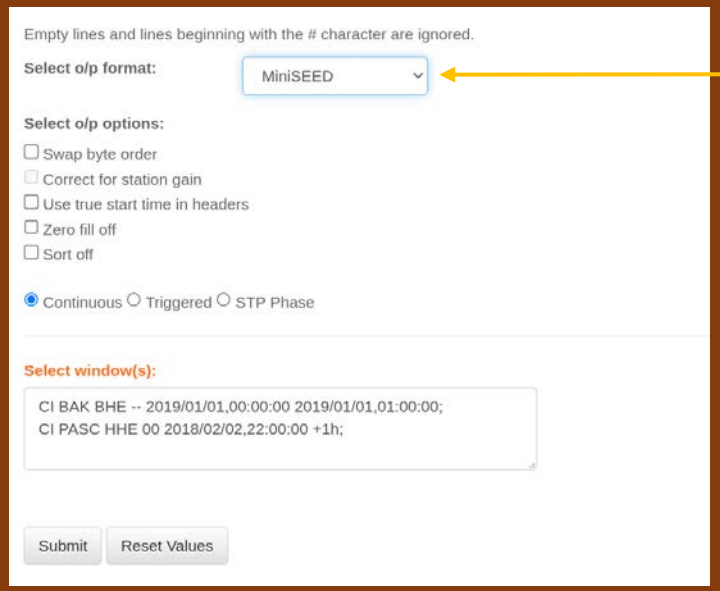


Twitter/X: @CaltechSeismo (and Facebook, Bluesky, Instagram, LinkedIn)

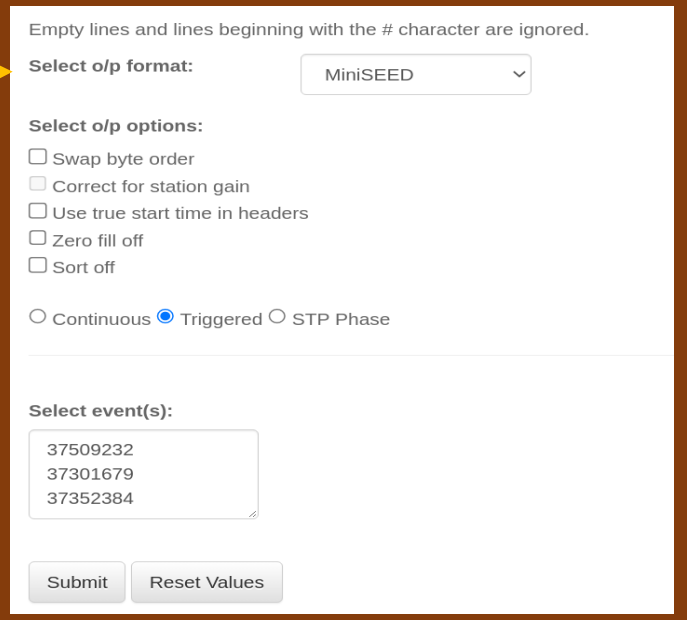
Extra Slides

Web STP serves as a web interface to the STP client; serves continuous waveform data as well as event waveform and phase data

https://service.scedc.caltech.edu/webstp/



- MiniSEED
- SAC
- INT32
- FLT32
- ASCII
- COSMOS-V0
- COSMOS-V1



Note: Requested time windows that don't fit this formula will return no data.
(timewindow / 1 / sr + 100) <= 400 * 1024 * 1024 / 4
where timewindow is end-start in seconds, sr is sample rate of the channel

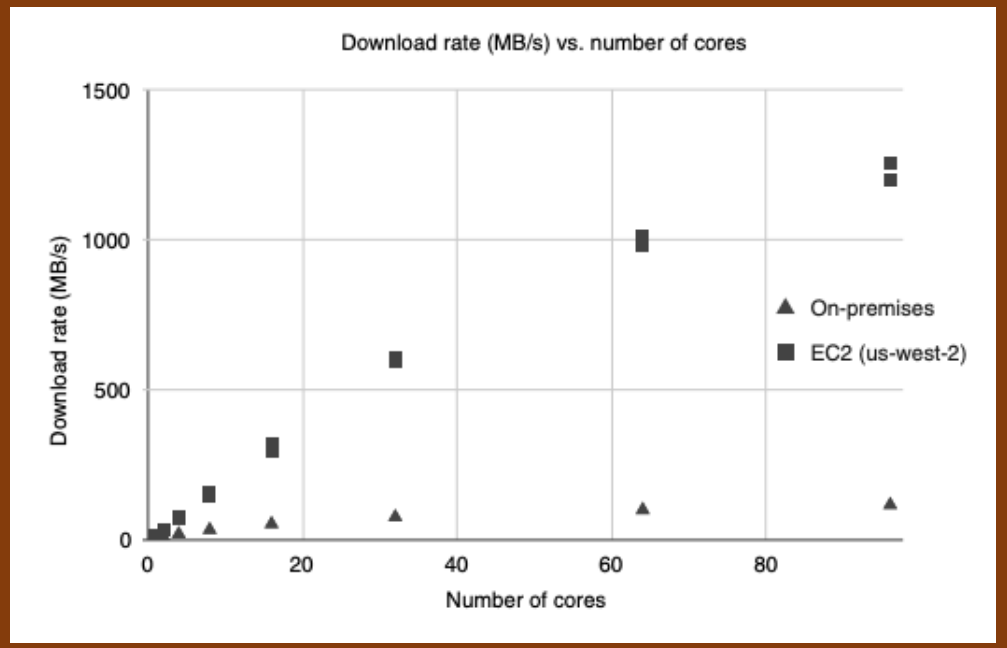
How to take advantage of cloud hosted data

*** **Use parallel processing** (remember 5,500 GET/HEAD requests /second/prefix!) ***

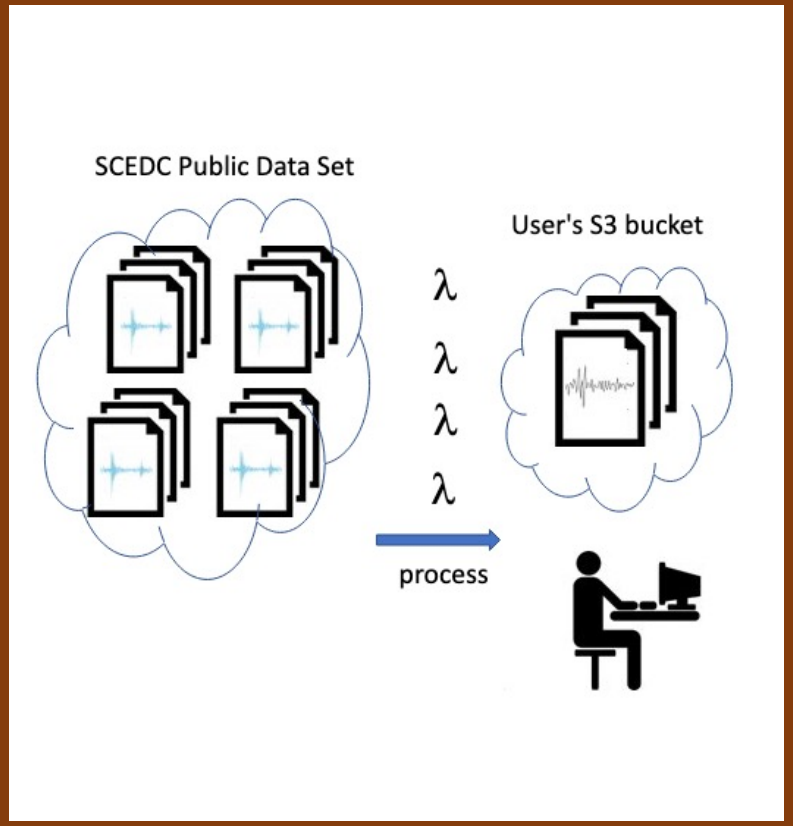
Take advantage of cloud services where appropriate

- Use the same region (us-west-2)
- Pay as you go
- Read the file in place for processing, store results in s3.

(Instead of downloading file and then process)



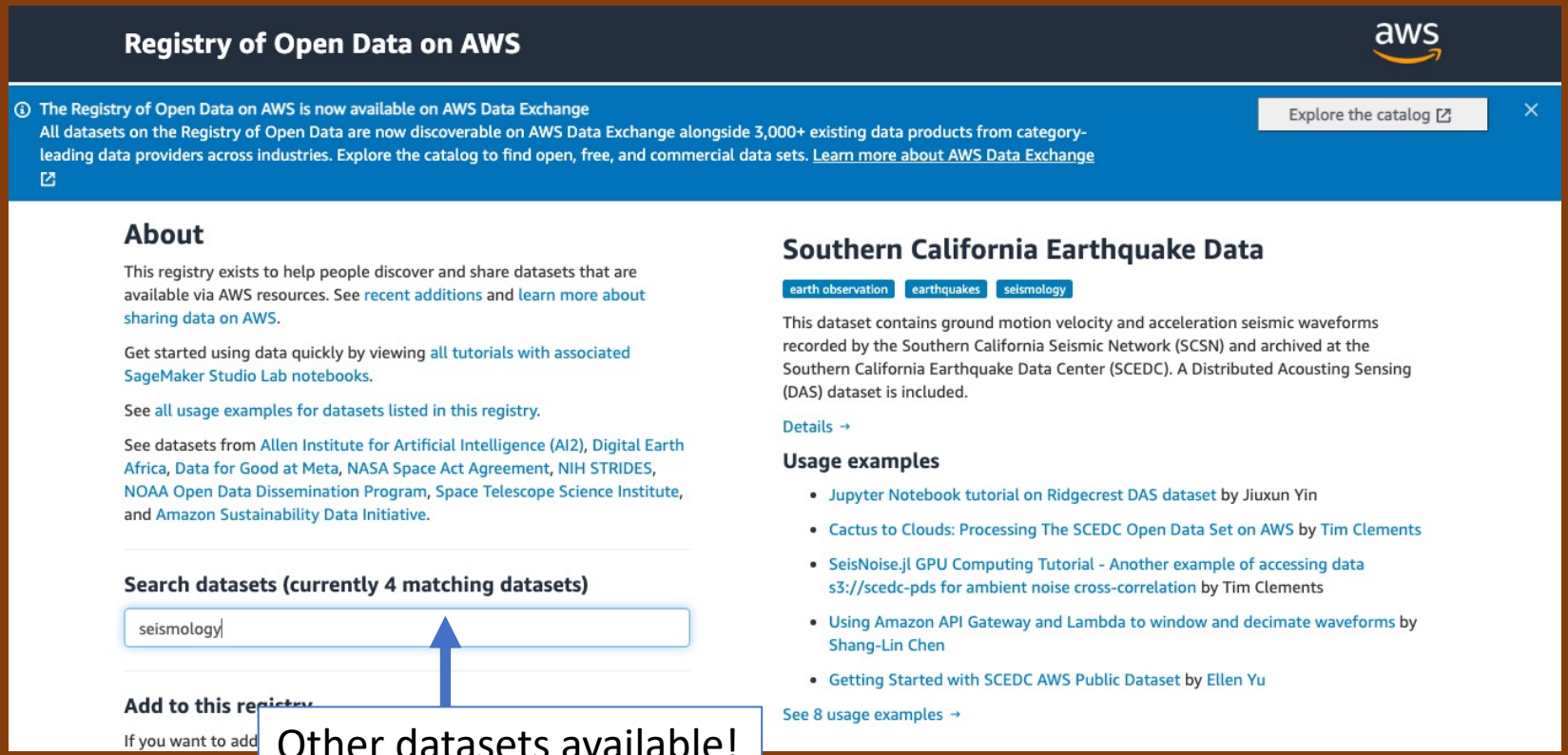
See https://github.com/SCEDC/tutorials



Data Access – AWS Open Dataset Program

AWS Open Dataset Program – Amazon covers the cost of storage for scientific datasets for providers whose goals are to:

- Democratize access to data by making it available for analysis on AWS
- Develop new cloud-native techniques, formats, and tools that lower the cost of working with data
- Encourage the development of communities that benefit from access to shared datasets
- SCEDC dataset currently in program – current agreement is until 2027.



Other datasets available!
NCEDC also has one!!!!

https://ncedc.org/aws-public-dataset.html

AWS Open Dataset - S3 Object Storage

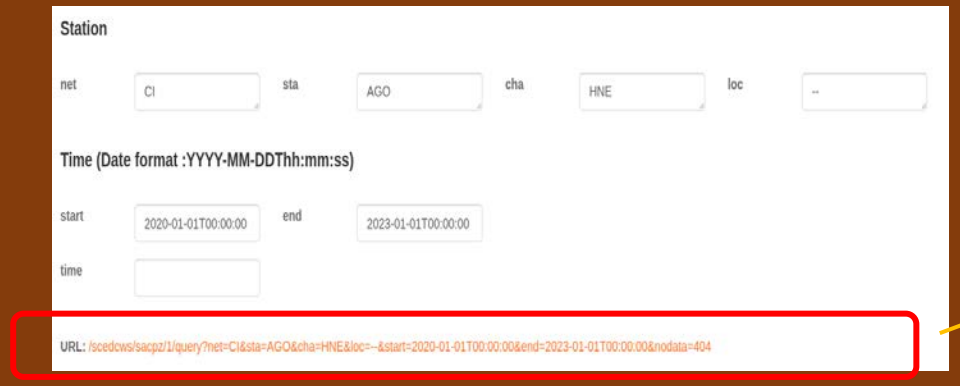
S3 = “Amazon Simple Storage Service”

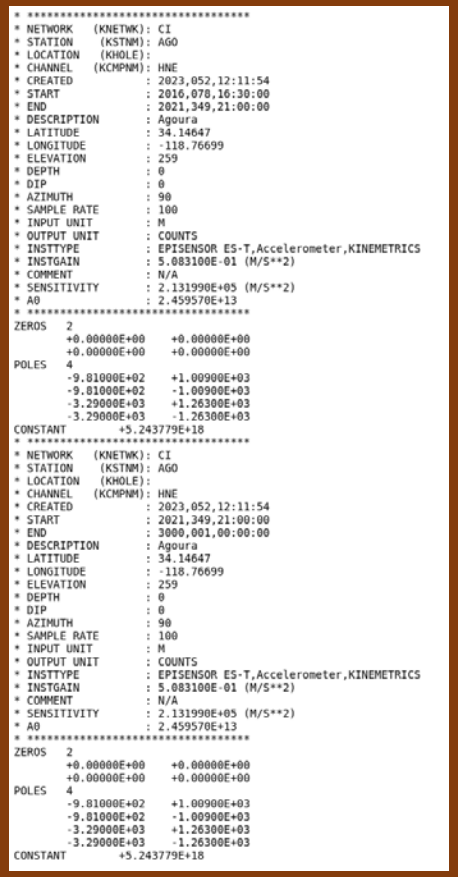
Object storage vs file system

- Technically, object storage is very flat, there are no directories – objects are organized by prefixes – but to the user it looks a lot like a directory
    - Ex: s3://scedc-pds/continuous_waveforms/2023/2023_078/CIPASC_BHE10_2023078.ms
    - Also means an API is required to access this data
- specialized for parallel requests – 5,500 GET/HEAD requests /second/prefix
- If you have to work with a file system – you can use something like s3fs

SCEDC SACPZ web service serves instrument response data in SACPZ format

https://service.scedc.caltech.edu/scedcws/sacpz/1/





```
* **********
* NETWORK   (KNETWK): CI
* STATION    (KSTNM): AGO
* LOCATION   (KHOLE):
* CHANNEL   (KCMPNM): HNE
* CREATED           : 2023,052,12:11:54
* START             : 2016,078,16:30:00
* END               : 2021,349,21:00:00
* DESCRIPTION       : Agoura
* LATITUDE          : 34.14647
* LONGITUDE         : -118.76699
* ELEVATION         : 259
* DEPTH             : 0
* DIP               : 0
* AZIMUTH           : 90
* SAMPLE RATE       : 100
* INPUT UNIT        : M
* OUTPUT UNIT       : COUNTS
* INSTTYPE          : EPISENSOR ES-T,Accelerometer,KINEMETRICS
* INSTGAIN          : 5.083100E-01 (M/S**2)
* COMMENT           : N/A
* SENSITIVITY       : 2.131990E+05 (M/S**2)
* A0                : 2.459570E+13
* **********
ZEROS   2
        +0.00000E+00    +0.00000E+00
        +0.00000E+00    +0.00000E+00
POLES   4
        -9.81000E+02    +1.00900E+03
        -9.81000E+02    -1.00900E+03
        -3.29000E+03    +1.26300E+03
        -3.29000E+03    -1.26300E+03
CONSTANT        +5.243779E+18
* **********
* NETWORK   (KNETWK): CI
* STATION    (KSTNM): AGO
* LOCATION   (KHOLE):
* CHANNEL   (KCMPNM): HNE
* CREATED           : 2023,052,12:11:54
* START             : 2021,349,21:00:00
* END               : 3000,001,00:00:00
* DESCRIPTION       : Agoura
* LATITUDE          : 34.14647
* LONGITUDE         : -118.76699
* ELEVATION         : 259
* DEPTH             : 0
* DIP               : 0
* AZIMUTH           : 90
* SAMPLE RATE       : 100
* INPUT UNIT        : M
* OUTPUT UNIT       : COUNTS
* INSTTYPE          : EPISENSOR ES-T,Accelerometer,KINEMETRICS
* INSTGAIN          : 5.083100E-01 (M/S**2)
* COMMENT           : N/A
* SENSITIVITY       : 2.131990E+05 (M/S**2)
* A0                : 2.459570E+13
* **********
ZEROS   2
        +0.00000E+00    +0.00000E+00
        +0.00000E+00    +0.00000E+00
POLES   4
        -9.81000E+02    +1.00900E+03
        -9.81000E+02    -1.00900E+03
        -3.29000E+03    +1.26300E+03
        -3.29000E+03    -1.26300E+03
CONSTANT        +5.243779E+18
```

SCEDC RESP web service serves instrument response data in RESP format

https://service.scedc.caltech.edu/scedcws/resp/1/


```
#
################################################################################
#
B050F03     Station:     AGO
B050F16     Network:     CI
B052F03     Location:    ??
B052F04     Channel:     HNE
B052F22     Start date:  2021,349,21:00:00
B052F23     End date:    3000,001,00:00:00
#
#                  +-------------------------------------+
#                  |    Response (Poles and Zeros)       |
#                  |        CI  AGO        HNE           |
#                  |     12/15/2021 to 01/01/3000        |
#                  +-------------------------------------+
#
B053F03     Transfer function type:                A
B053F04     Stage sequence number:                 1
B053F05     Response in units lookup:              M/S**2 - ACCELERATIO
B053F06     Response out units lookup:             V - VOLTAGE
B053F07     A0 normalization factor:               +2.45957E+13
B053F08     Normalization frequency:               +1.00000E+00
B053F09     Number of zeroes:                      0
B053F14     Number of poles:                       4
#               Complex poles:
#                 i  real          imag          real_error    imag_error
B053F15-18      0  -9.81000E+02  +1.00900E+03  +0.00000E+00  +0.00000E+0
B053F15-18      1  -9.81000E+02  -1.00900E+03  +0.00000E+00  +0.00000E+0
B053F15-18      2  -3.29000E+03  +1.26300E+03  +0.00000E+00  +0.00000E+0
B053F15-18      3  -3.29000E+03  -1.26300E+03  +0.00000E+00  +0.00000E+0
#
#                  +-------------------------------------+
#                  |      Channel Sensitivity/Gain       |
#                  |        CI  AGO        HNE           |
#                  |     12/15/2021 to 01/01/3000        |
#                  +-------------------------------------+
#
B058F03     Stage sequence number:                 1
B058F04     Sensitivity:                           +5.08310E-01
B058F05     Frequency of sensitivity:              +1.00000E+00
B058F06     Number of calibrations:                0
```

FDSN Event web service serves earthquake or event parametric information

https://service.scedc.caltech.edu/fdsnws/event/1/

ObsPy Support

- **SCEDC**
- DS2000
- HAUK2003
- HAUK2004
- SHLK2005
- YHS2011

URL Builder

Earthquake Parameters

Start Time: 2019-07-06T00:00:00
End Time: 2019-07-07T00:00:00
Min Mag: 4
Max Mag: 9
Min Depth:
Max Depth:
Contributor: SCSN
Catalog: SCEDC

Location (all inputs are in decimal degrees)➤
Min Lat / Max Lat / Min Lon / Max Lon

Ring Radius (all inputs are in decimal degrees)➤
Lat / Lon / Min Radius / Max Radius

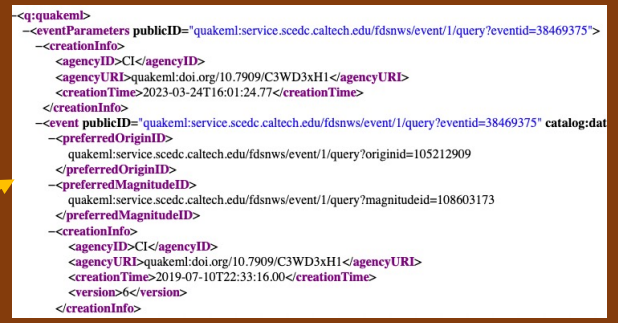
Event ID ➤

Others ➤
Event Types: Any
Geographic Types: Any
Mag Types: All
☐ Include all magnitudes
☐ Include arrivals
☐ Include mechanisms

Output ➤
Offset:
Limit:
Order By: time (descending)
Format: xml

URL: /fdsnws/event/1/query?starttime=2019-07-06T00:00:00&endtime=2019-07-07T00:00:00&minmag=4&maxmag=9&catalog=SCEDC&etype=any&gtype=any&magtype=all&orderby=time&format=xml&nodata=404

- QuakeML
- Text



FDSN Station web service serves metadata for waveform time series

https://service.scedc.caltech.edu/fdsnws/station/1/

URL Builder

Station

net: CI | sta: AGO | cha: HNE | loc: --

Location (all inputs are in decimal degrees) ➤

Ring Radius (all inputs are in decimal degrees) ➤

Time (Date format: YYYY-MM-DDThh:mm:ss)

Note: Time filters are applied against channel epochs.

start before | start after

end before | end after

start | end

updated after

Output

Format: xml

Details Level

level: response

Data Availability

Include Availability: false

URL:/fdsnws/station/1/query?net=CI&sta=AGO&cha=HNE&loc=--&level=response&format=xml&includeavailability=false&nodata=404

Location (all inputs are in decimal degrees) ➤

Min Lat | Max Lat

Min Lon | Max Lon

Ring Radius (all inputs are in decimal degrees) ➤

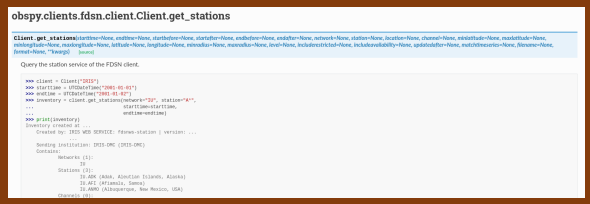
Lat | Lon

Min Radius | Max Radius

- FDSN Station XML
- Text

- Network
- Station
- Channel
- Response

ObsPy Support



FDSN Dataselect web service serves continuous waveform time series data in miniSEED

https://service.scedc.caltech.edu/fdsnws/dataselect/1/

URL Builder

Station

net: CI

sta: AGI

cha: HNE

loc: --

Use dashes (-) instead of blank spaces.
For e.g. loc=--

Time & Quality

start: 2023-01-01T00:00:00

end: 2023-01-01T00:10:00

Quality:

Output

Format: miniseed

URL: /fdsnws/dataselect/1/query?net=CI&sta=AGI&cha=HNE&loc=--&start=2023-01-01T00:00:00&end=2023-01-01T00:10:00&format=miniseed&nodata=404

Continuous waveform data

No event waveform support

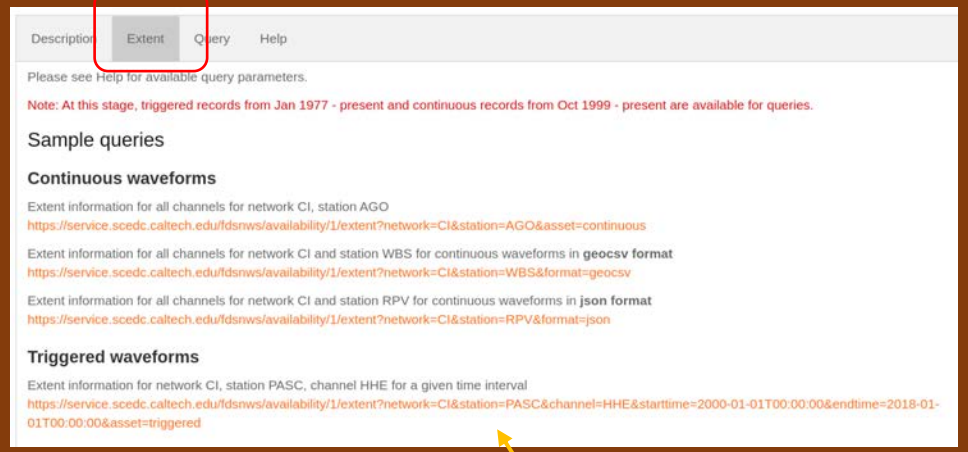
ObsPy Support

Note: Requested time windows that don't fit this formula will return no data.
(timewindow / 1 / sr + 100) <= 400 * 1024 * 1024 / 4
where timewindow is end-start in seconds, sr is sample rate of the channel

For large downloads, use the AWS Open Data Set, not FDSN Dataselect

FDSN Availability web service serves time span information for what time series data are available (miniSEED only)

https://service.scedc.caltech.edu/fdsnws/availability/1/

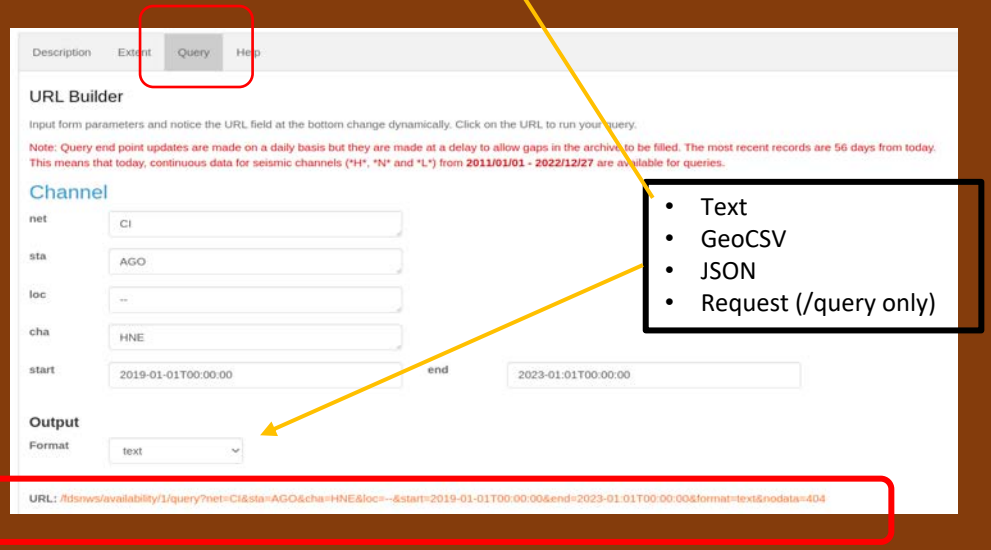


Extent produces lists of available time extents (earliest to latest) for selected channels (network, station, channel, location) and time ranges. Extents can be queried for both continuous and triggered waveform data.

/extent:

- triggered records from Jan 1977 - present
- continuous records from Oct 1999 - present

```
#Network Station Location Channel Quality SampleRate Earliest Latest Updated TimeSpans Restriction
CI AGO -- EHZ D 100.00 2003-02-22T06:00:02.060000Z 2023-03-20T05:55:01.000000Z NA NA OPEN
CI AGO -- HLE D 100.00 2003-02-22T05:59:59.720000Z 2006-05-24T06:00:00.990000Z NA NA OPEN
CI AGO -- HLN D 100.00 2003-02-22T05:59:58.360000Z 2006-05-24T06:00:00.990000Z NA NA OPEN
CI AGO -- HLZ D 100.00 2003-02-22T05:59:58.440000Z 2006-05-24T06:00:00.990000Z NA NA OPEN
CI AGO -- HNE D 100.00 2010-01-01T00:00:04.980000Z 2023-03-20T05:57:04.000000Z NA NA OPEN
CI AGO -- HNN D 100.00 2010-01-01T00:00:01.550000Z 2023-03-20T05:54:44.000000Z NA NA OPEN
CI AGO -- HNZ D 100.00 2010-01-01T00:00:03.980000Z 2023-03-20T05:54:48.000000Z NA NA OPEN
CI AGO -- LCE D 1.00   2014-03-31T23:52:52.000000Z 2023-03-20T05:55:00.000000Z NA NA OPEN
CI AGO -- LCQ D 1.00   2014-03-31T23:54:55.000000Z 2023-03-20T05:55:00.000000Z NA NA OPEN
CI AGO -- LEB D 1.00   2014-03-31T23:54:35.000000Z 2023-03-20T05:55:00.000000Z NA NA OPEN
CI AGO -- LEC D 1.00   2014-03-31T23:57:48.000000Z 2023-03-20T05:55:00.000000Z NA NA OPEN
CI AGO -- LEP D 1.00   2014-03-31T23:54:46.000000Z 2023-03-20T05:55:00.000000Z NA NA OPEN
CI AGO -- LII D 1.00   2014-03-31T23:55:06.000000Z 2023-03-20T05:55:00.000000Z NA NA OPEN
CI AGO -- LKI D 1.00   2014-03-31T23:54:21.000000Z 2023-03-20T05:55:00.000000Z NA NA OPEN
CI AGO -- LNE D 1.00   2014-03-30T23:50:27.000000Z 2023-03-20T05:55:00.000000Z NA NA OPEN
CI AGO -- LNN D 1.00   2014-03-30T23:50:09.000000Z 2023-03-20T05:55:00.000000Z NA NA OPEN
CI AGO -- LNZ D 1.00   2014-03-30T23:51:08.000000Z 2023-03-20T05:55:00.000000Z NA NA OPEN
```



- Text
- GeoCSV
- JSON
- Request (/query only)

Query produces lists of continuous time spans for selected channels (network, station, channel, location) and time ranges. Query is available only for continuous waveform data.

/query

- continuous records (*H*, *N* and *L*) from Jan 01, 2011 - Jan 23, 2023

#dataset: GeoCSV 2.0
#delimiter : |
#field_unit : unitless | unitless | unitless | unitless | unitless | hertz | ISO_8601 | ISO_8601 | ISO_8601 | unitless | unitless
#field_type : string | string | string | string | string | float | datetime | datetime | datetime | integer | string
Network|Station|Location|Channel|Quality|SampleRate|Earliest|Latest|Updated|TimeSpans|Restriction
CI|AGO||HNE|D|100.00|2022-01-01T00:00:00.000000Z|2022-01-01T23:59:59.990000Z|NA|NA|OPEN
CI|AGO||HNE|D|100.00|2022-01-02T00:00:00.000000Z|2022-01-02T23:59:59.990000Z|NA|NA|OPEN
CI|AGO||HNE|D|100.00|2022-01-03T00:00:00.000000Z|2022-01-03T22:01:06.992000Z|NA|NA|OPEN
CI|AGO||HNE|D|100.00|2022-01-03T22:01:07.999000Z|2022-01-03T22:01:10.992000Z|NA|NA|OPEN
CI|AGO||HNE|D|100.00|2022-01-03T22:01:11.999000Z|2022-01-03T22:01:12.992000Z|NA|NA|OPEN
CI|AGO||HNE|D|100.00|2022-01-03T22:01:13.999000Z|2022-01-03T22:01:14.992000Z|NA|NA|OPEN
CI|AGO||HNE|D|100.00|2022-01-03T22:01:16.999000Z|2022-01-03T23:59:59.990000Z|NA|NA|OPEN
CI|AGO||HNE|D|100.00|2022-01-04T00:00:00.000000Z|2022-01-04T23:59:59.990000Z|NA|NA|OPEN
CI|AGO||HNE|D|100.00|2022-01-05T00:00:00.000000Z|2022-01-05T23:59:59.990000Z|NA|NA|OPEN
CI|AGO||HNE|D|100.00|2022-01-06T00:00:00.000000Z|2022-01-06T23:59:59.990000Z|NA|NA|OPEN
CI|AGO||HNE|D|100.00|2022-01-07T00:00:00.000000Z|2022-01-07T23:59:59.990000Z|NA|NA|OPEN
CI|AGO||HNE|D|100.00|2022-01-08T00:00:00.000000Z|2022-01-08T23:59:59.990000Z|NA|NA|OPEN
CI|AGO||HNE|D|100.00|2022-01-09T00:00:00.000000Z|2022-01-09T01:14:32.992000Z|NA|NA|OPEN
CI|AGO||HNE|D|100.00|2022-01-09T01:15:53.999000Z|2022-01-09T23:59:59.990000Z|NA|NA|OPEN
CI|AGO||HNE|D|100.00|2022-01-10T00:00:00.000000Z|2022-01-10T00:00:00.000000Z|NA|NA|OPEN

Other STP Commands

- eavail – list available waveforms for an event
- avail – list stations channels
- phase – search for phase picks by event, net/sta/channel, or time
- in – read and run commands from an input file
- help

- STP is scriptable – put commands in a file and feed them to the client

```
cat commands.txt | stp
```

STP Query Language

- Search for events between magnitudes 3 and 5 on a particular day:

```
event –t0 2023/01/25,00:00:00 +1d –mag 3 5
```

- Download waveforms for event ID 12345 from a CI.AGO HH* channels:

```
trig –net CI –sta AGO –chan HH_ 12345
```

- Download continuous waveforms from CI.AGO.H* for the last two hours:

```
win –net CI –sta AGO –chan HH_ –2h +2h
```

STP Etiquette

- STP servers support a limited number of simultaneous clients
- Don't run more than a few (2-3) parallel client processes
- Client processes running more than 4 hours may be turned off
- Check the message of the day for announcements when you log in

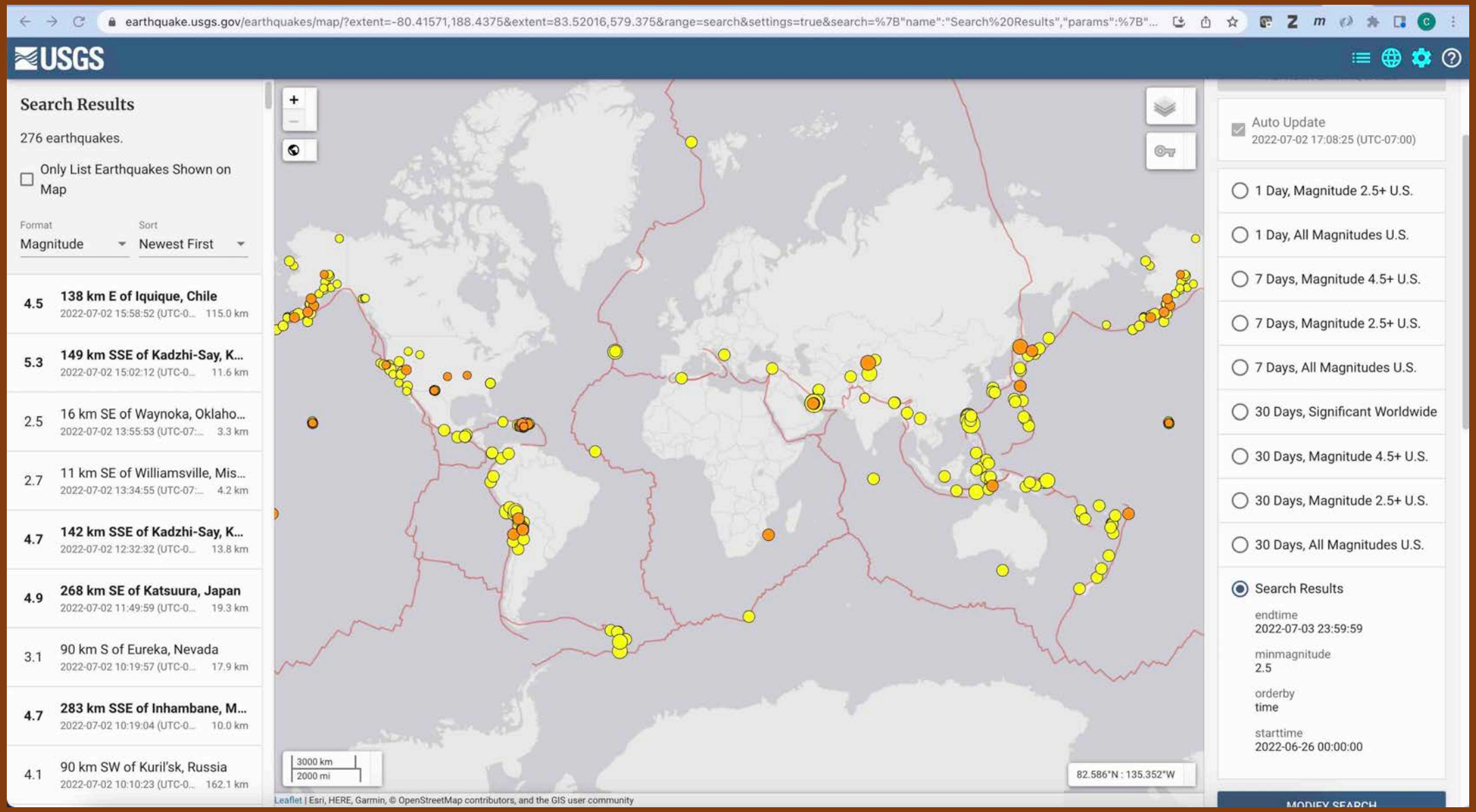
- For large downloads, use the SCEDC AWS Public Dataset

C Client

- Classic STP client is a user-downloadable C program
- Compiled with Make and gcc compiler
- Mac, Linux, Windows (WSL, Cygwin)
- Precompiled Cygwin executable is also available

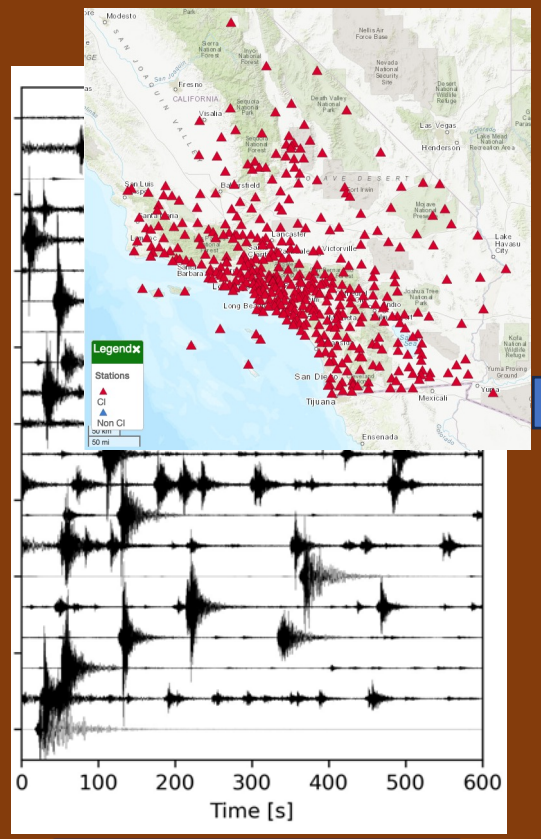
ComCat: Global Earthquake Catalog

https://earthquake.usgs.gov/earthquakes/search/



Earthquake Catalog Workflow Steps

INPUT



Seismic Data

First motion polarity

S/P amplitude ratio

Phase Detection & Picking — AQMS/Earthworm STA/LTA (automatic); Jiggle (manual)

Phase Association — AQMS/Earthworm binder

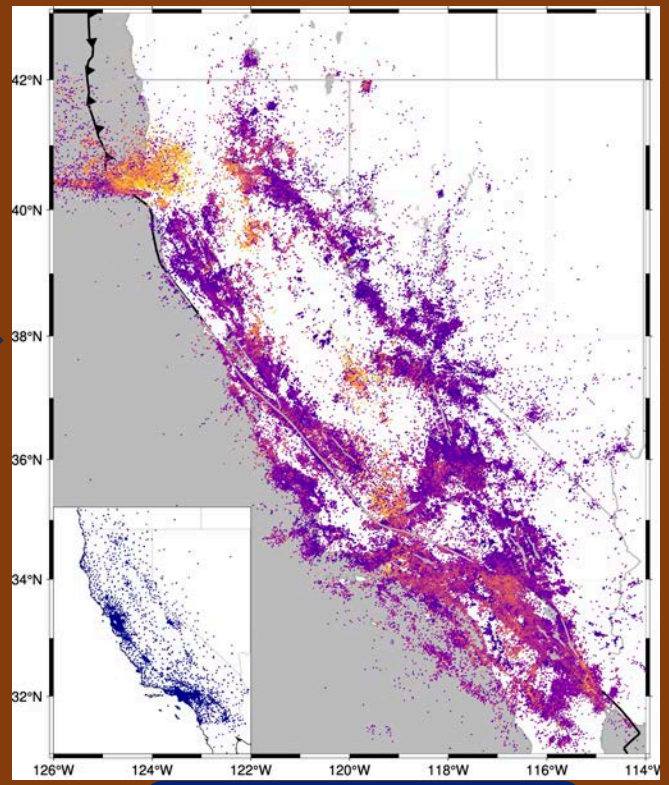
Earthquake Location — HYPOINVERSE, 1D 4-layer velocity model
Hadley and Kanamori (1977)

Earthquake Magnitude — Ml for all (Mlr if >3.5) Mw for M>3.5**

Focal Mechanism / Moment Tensor — HASH / TMTS

Auto Post-process M<2.95
Manual review

OUTPUT



Earthquake Catalog

*AQMS: ANSS Quake Monitoring System
*STA/LTA: short-term-average / long-term-average (ratio)

**When available (sometimes can't be determined reliably)

Waveforms – Instrumentation (SCSN)

- Most common set-up
  - data logger: Quanterra Q330S or Q8
  - broadband seismometer: STS-2 (typical), Guralp CMG-3T, MBB-1/2, Kinemetrics OMNISensor, PBB-200S, STS-1
  - triaxial strong motion accelerometer: Episensor EST

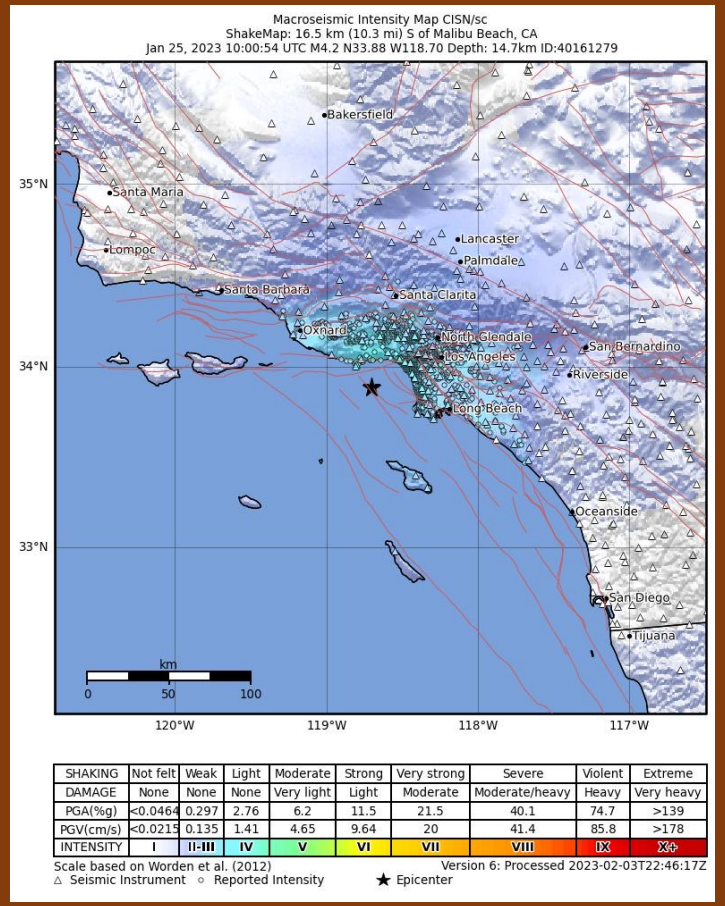
- Alternate (on the way out)
  - data logger: Basalt/Obsidian 4 channel
  - strong motion: Episensor
  - short period vertical: usually an L4

- Previous (no longer used)
  - short-period (L4) only
  - STS-1 seismometer + pressure sensor

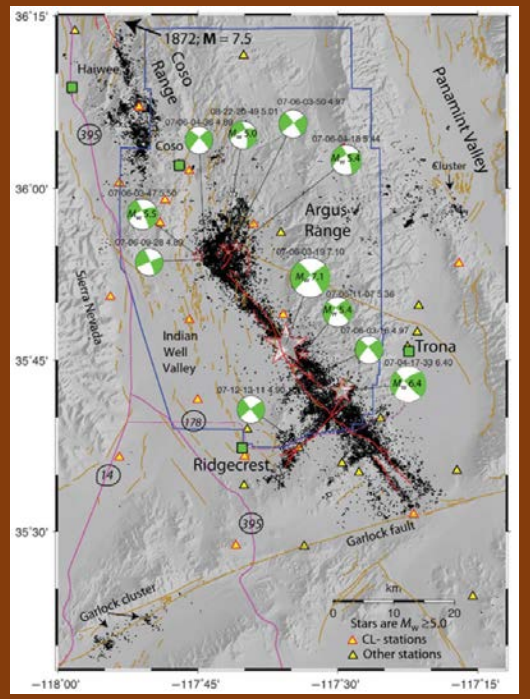
- Other Notes
  - GSN station: PASC
  - a few borehole stations & building arrays
    - one borehole (MIK/MIKB) has a rotational sensor
  - NetQuake stations (Q*): digitizer+strong motion

Other Products & Special Datasets

ShakeMaps



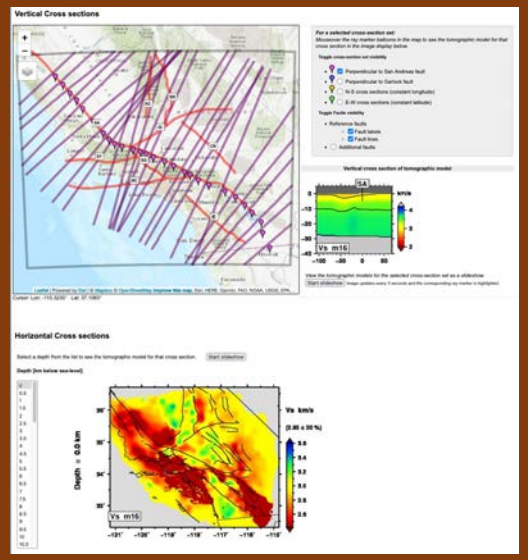
Ridgecrest Datasets



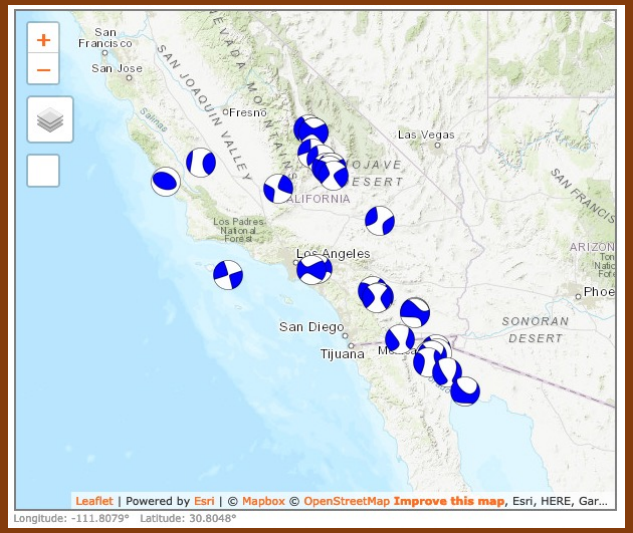
ML Training & Validation Datasets

And more!

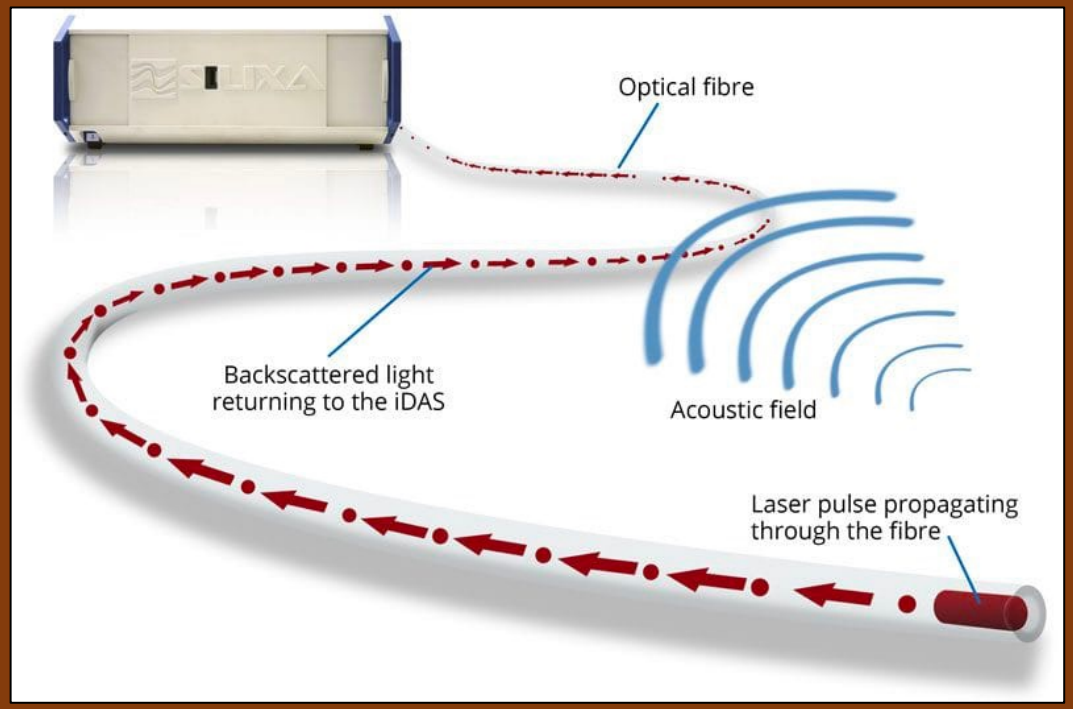
Interactive Tomographic Map & 3D Velocity Model



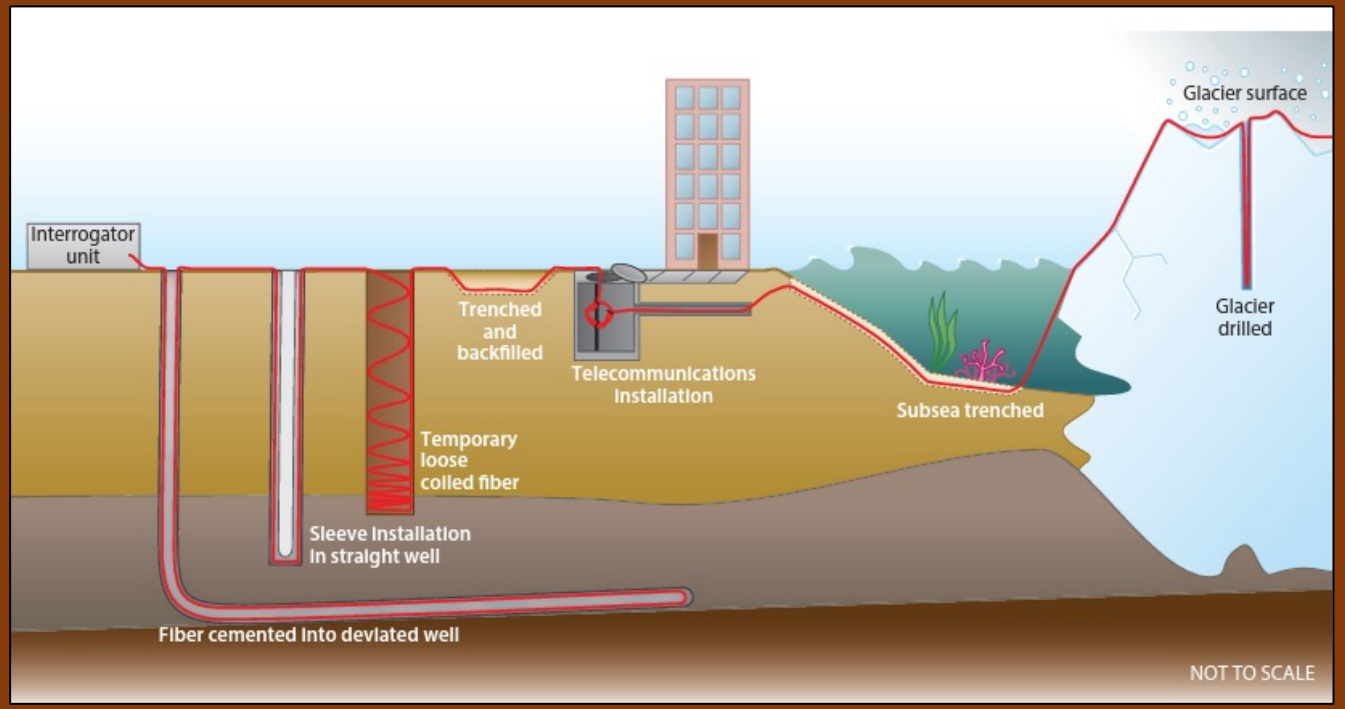
W Phase Moment Tensors



Special Datasets: Distributed acoustic sensing data

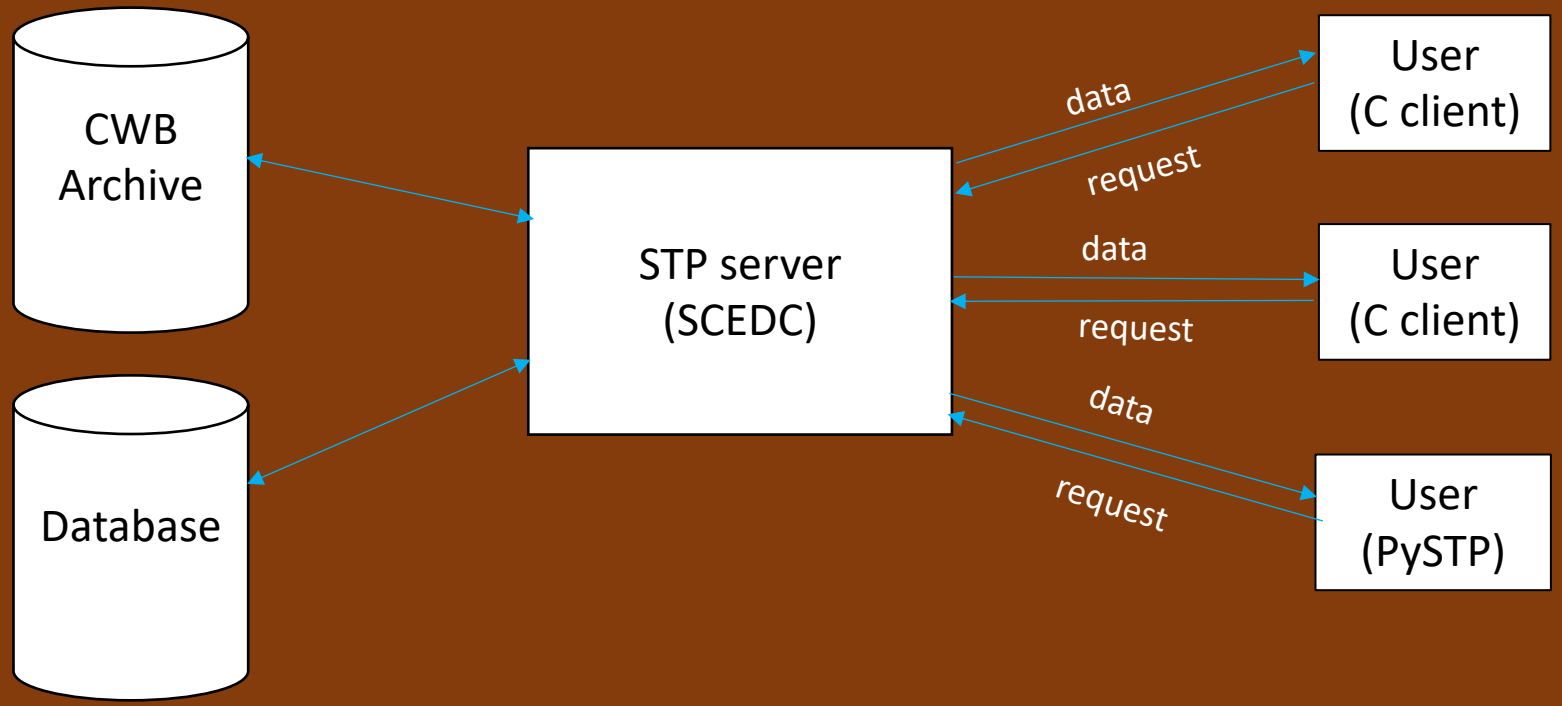


Shatalin et al., 2020

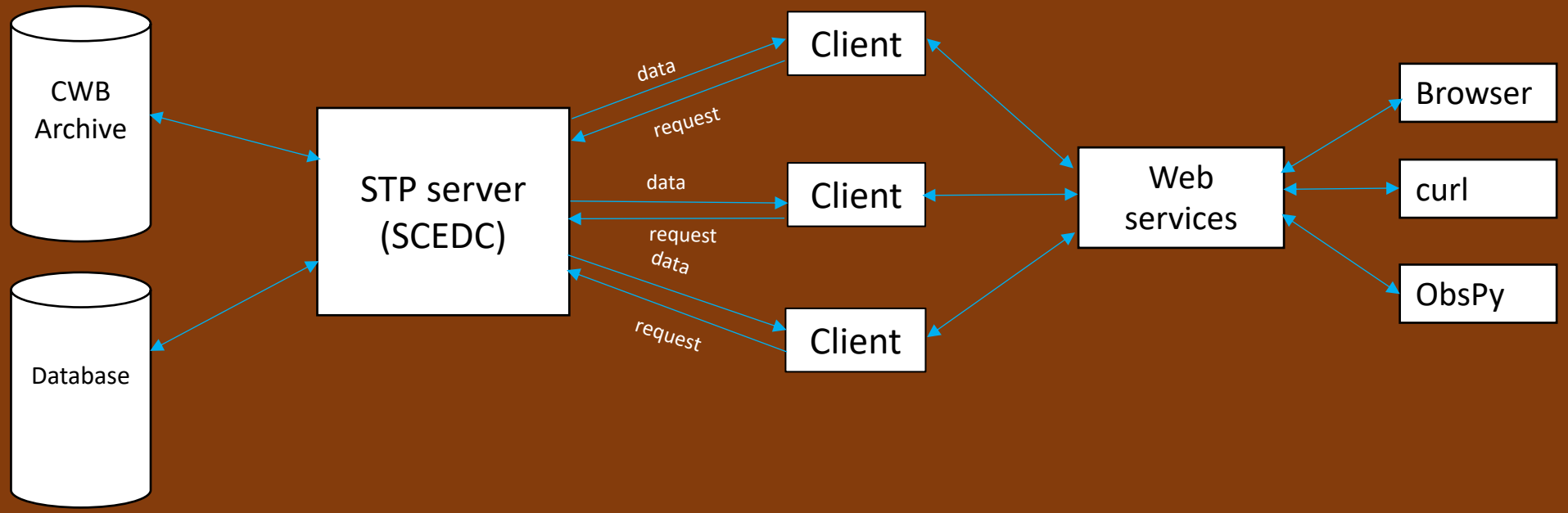


Lindsey and Martin, 2021

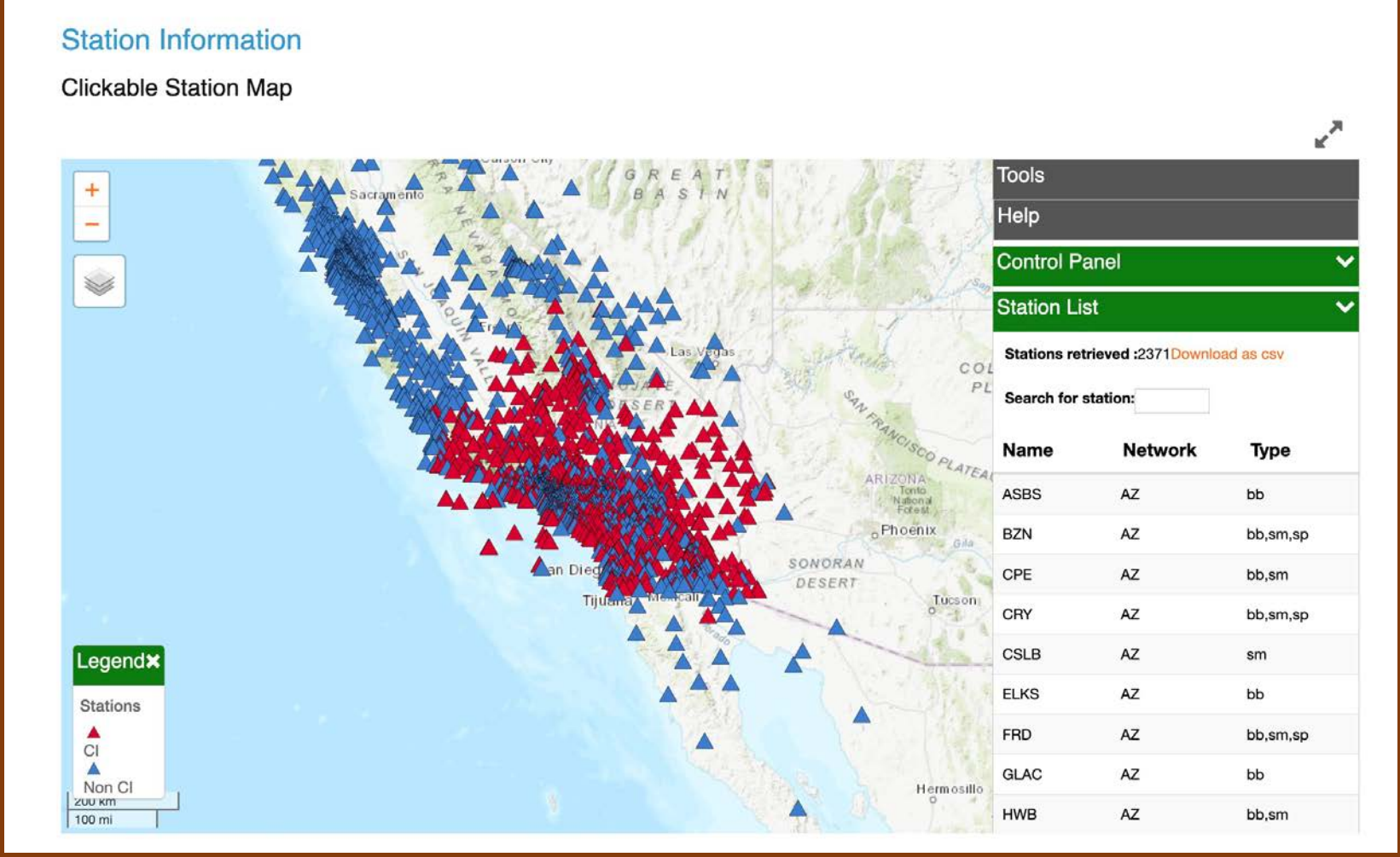
Client/Server Model



STP and Web Services

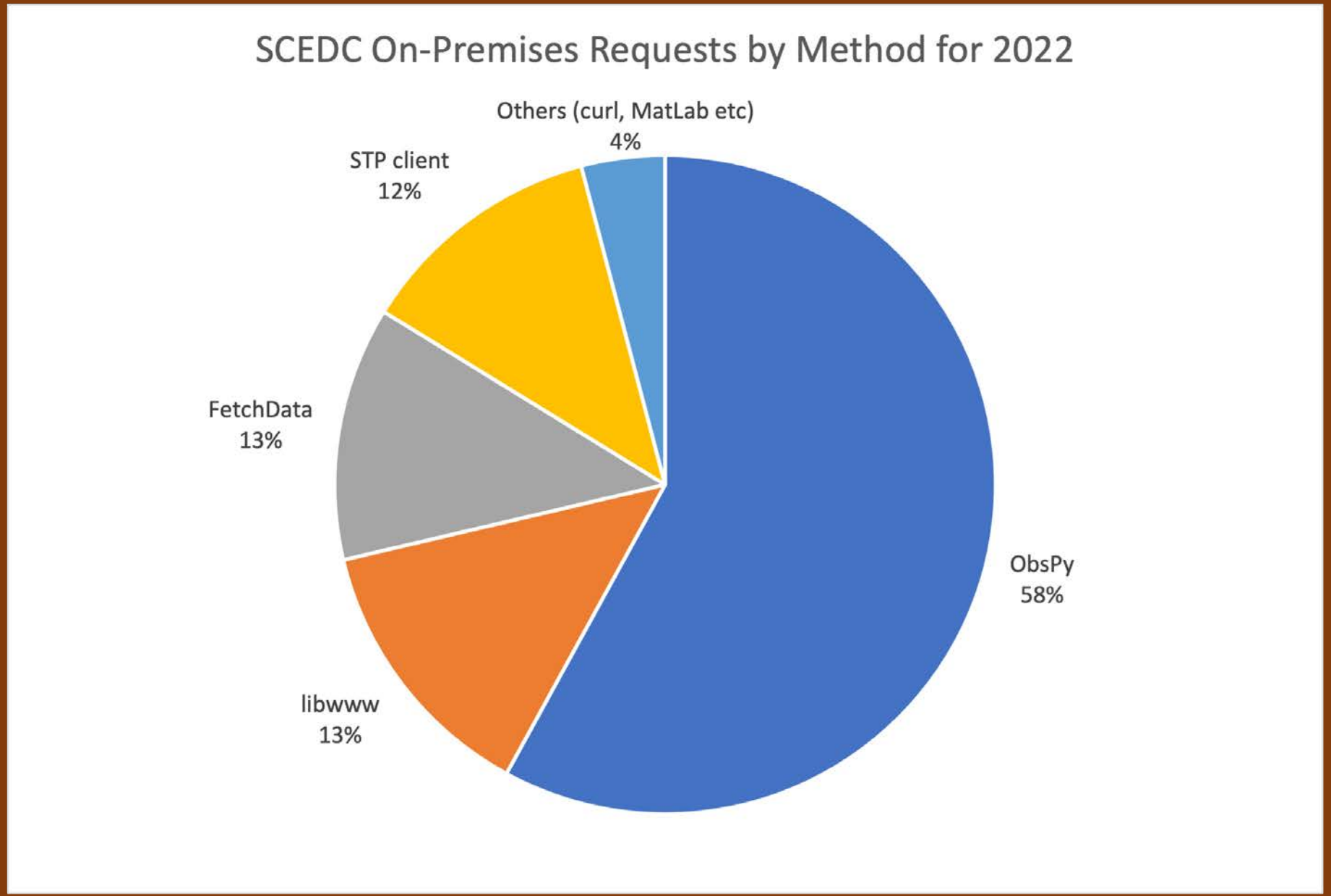


Data Access – Website – Station Metadata



Clickable Station Map

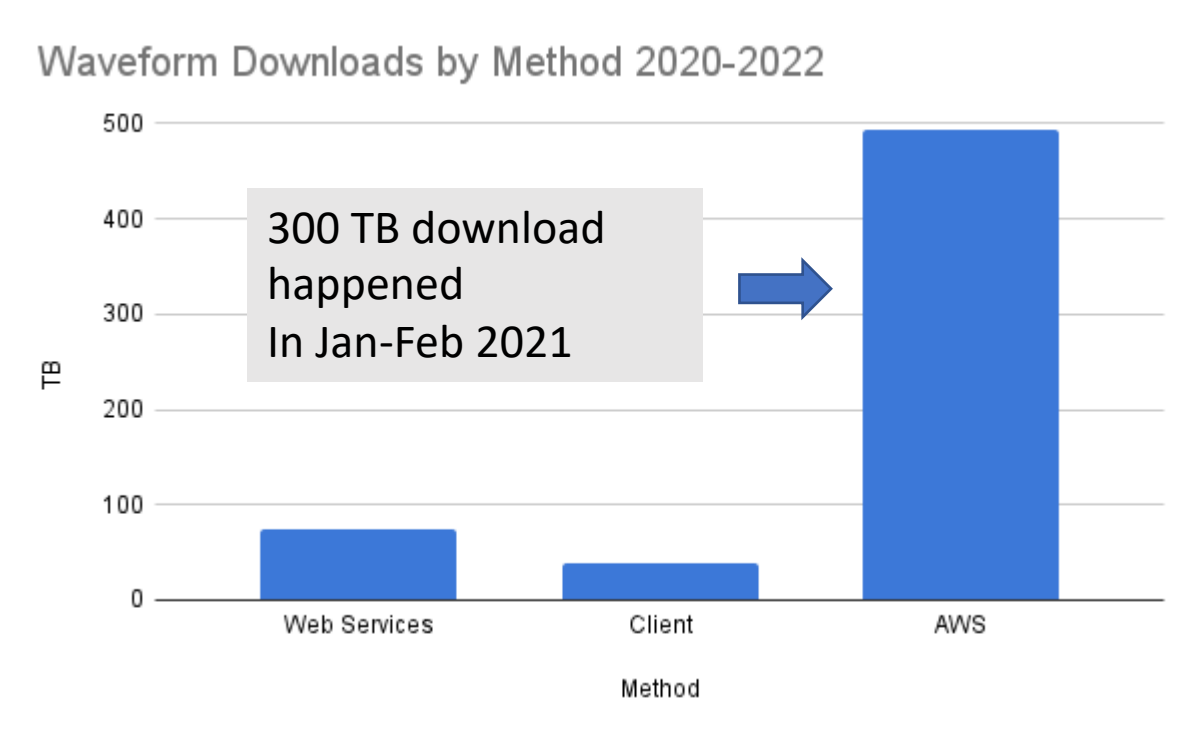
- Good for data discovery
- Shows stations that have an entry in SCEDC archive.
- Can filter by time, sensor type, and network code.
- Can out results to csv.


SCEDC On-Premises Requests by Method for 2022
Others (curl, MatLab etc)
4%
STP client
12%
FetchData
13%
libwww
13%
ObsPy
58%

PySTP Usage

```
from pystp import STPClient
import datetime

stp = STPClient()
stp.connect()

# Get catalog of M4-5 events on Jan. 25, 2023.
events = stp.get_events(times  = [datetime.datetime(2023, 1, 25), datetime.datetime(2023, 1, 26)], mags=[4, 5])

# Get the event ID of the first event in the catalog.
evid = events[0].resource_id
# Download waveforms.
waveform = stp.get_trig([evid], net='CI', sta='BAK', chan="HH_")
waveform[evid].plot(outfile='CI_BAK_HH.png')
stp.disconnect()
```

Cloud access stats



We've seen file access rates as high as 2GB/s!

M 7.0 – 2024 Offshore Cape Mendocino, California Earthquake

2024-12-05 18:44:21 (UTC) | 40.374°N 125.022°W | 10.0 km depth

Preferred moment tensor
Contributes preferred magnitude: Mww 7.0

Moment Tensor

View all moment-tensor products (2 total)

Available Moment Tensor Products

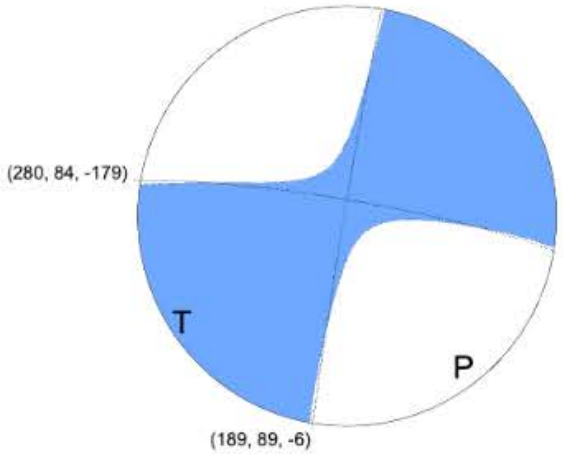
Catalog	Tensor	Magnitude	Depth	% DC	Source
US ✓		7.0 Mww	11.5 km	87 %	US
US		6.9 Mwb	16.0 km	92 %	US

Contributed by US last updated 2025-02-15 18:29:50 (UTC)

✓ The data below are the most preferred data available
✓ The data below have been reviewed by a scientist

W-phase Moment Tensor (Mww)

Moment	4.028e+19 N-m
Magnitude	7.00 Mww
Depth	11.5 km
Percent DC	87%
Half Duration	7.50 s
Catalog	US
Data Source	US
Contributor	US



Nodal Planes

Plane	Strike	Dip	Rake
NP1	280°	84°	-179°
NP2	189°	89°	-6°

Principal Axes

Axis	Value	Plunge	Azimuth
T	3.888e+19	4°	235°
N	0.267e+19	84°	359°
P	-4.155e+19	5°	144°

Downloads

Earthquake XML (Quakeml)

- XML 65.3 KB

M 7.0 – 2024 Offshore Cape Mendocino, California Earthquake

2024-12-05 18:44:21 (UTC) | 40.374°N 125.022°W | 10.0 km depth

Preferred focal mechanism

Focal Mechanism

View all focal-mechanism products (2 total)

Available Focal Mechanism Products

Catalog	Mechanism	Nodal Plane 1	Nodal Plane 2	Source		
NC ✓	NC ✓		285° , 80° , 180°	14° , 90° , 10°	NC	NC
NC ✓	NC ✓		135° , 10° , -60°	284° , 81° , -95°	NC	NC

Contributed by NC last updated 2024-12-06 00:11:11 (UTC)

✓ The data below are the most preferred data available

⊗ The data below have **NOT** been reviewed by a scientist.

Catalog	NC
Data Source	NC
Contributor	NC

Nodal Planes

Plane	Strike	Dip	Rake
NP1	285°	80°	180°
NP2	15°	90°	10°

Downloads

NCSN First Motion Mechanism 2

NCSN First Motion Mechanism 2

- GIF 14.2 KB
- XML 13.0 KB

Polarity at each station: see xml