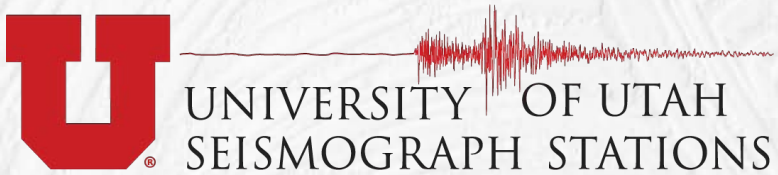
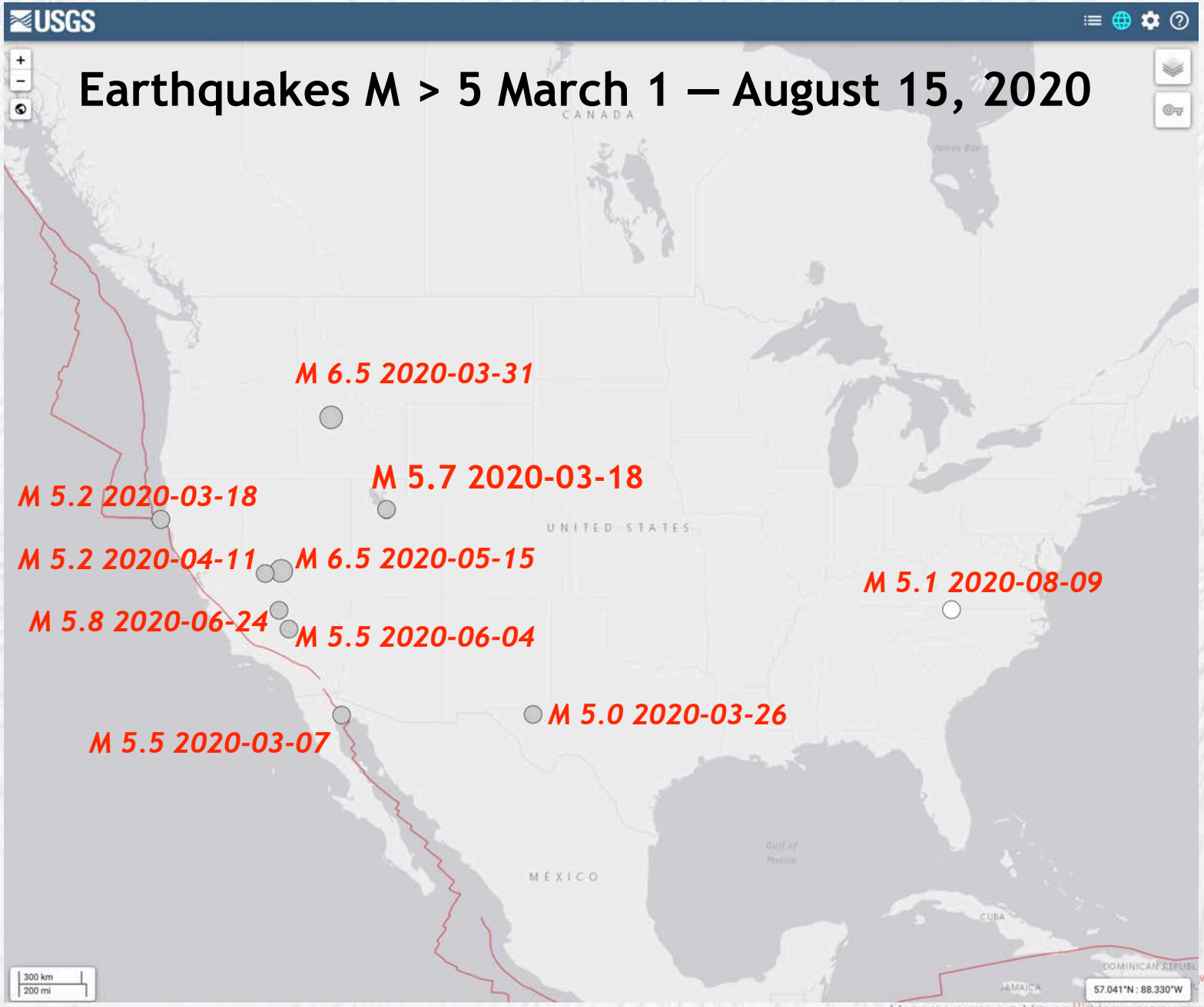
Earthquakes Don't Stop for Pandemics

Kristine Pankow



ICDP Lunch and Learn

26 August 2020


USGS
Earthquakes M > 5 March 1 — August 15, 2020
CANADA
UNITED STATES
MÉXICO
CUBA
M 6.5 2020-03-31
M 5.7 2020-03-18
M 5.2 2020-03-18
M 5.2 2020-04-11
M 6.5 2020-05-15
M 5.1 2020-08-09
M 5.8 2020-06-24
M 5.5 2020-06-04
M 5.0 2020-03-26
M 5.5 2020-03-07
300 km
200 mi
57.041°N : 88.330°W

… but the Earth Gets Quieter

Science

Earthquake sensors record unprecedented drop in human activity due to pandemic

Such a sweeping effect has never been seen in the history of earthquake science

With Covid-19, a Seismic Quiet Like No Other

Coronavirus shutdowns led to "the longest and most coherent global seismic noise reduction in recorded history," scientists report.

SCIENCE | CORONAVIRUS COVERAGE

These charts show how coronavirus has 'quieted' the world

As people stopped commuting and traveling, the Earth's surface vibrated less —and seismologists tracked the change.

Explained: How Covid-19 lockdowns caused a drop in seismic noise levels worldwide

High frequency noise caused by human activities dropped by as much as 50 p and May this year, according to researchers.

NEWS EARTH

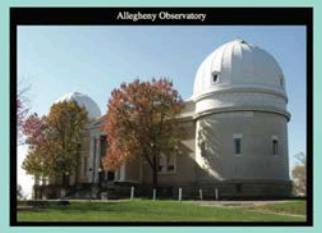
COVID-19 lockdowns dramatically reduced seismic noise from humans

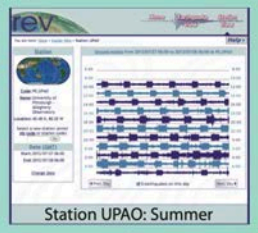
Small ground vibrations generated by everyday activities dropped up to 50 percent in places

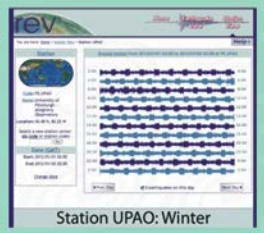
Examples of Seismic Noise

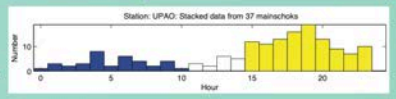
Kilb et al. (2012)

Air Circulation System



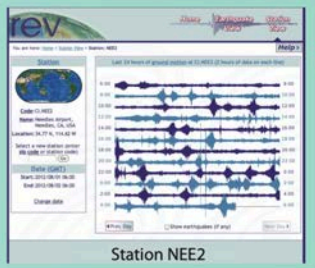


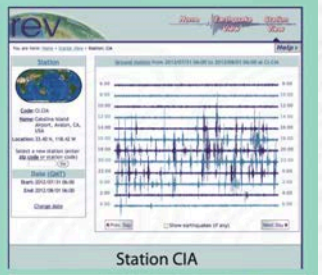


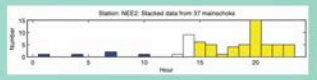


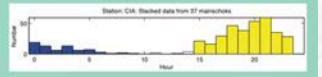
- [x] Time of day histograms show most detections are in the daytime.
- [x] Waveform data shows detections are likely not seismic.
- [x] Do not select this station for use in our initial beta-testing (i.e., detections likely non-seimsic).
- [ ] Select this station for use in our initial beta-testing (i.e., detections likely seismic).

Airports









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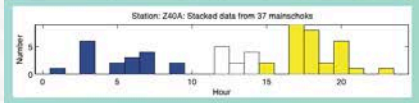
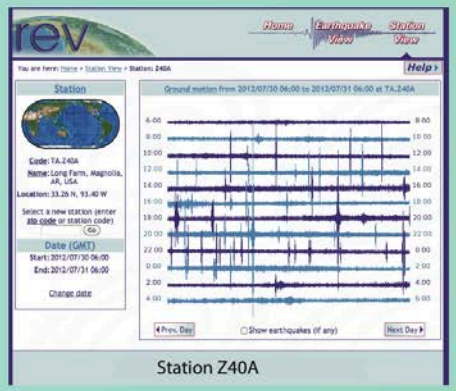
- [ ] Select this station for use in our initial beta-testing (i.e., detections likely seismic).

Farms (e.g., cows)

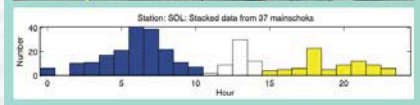


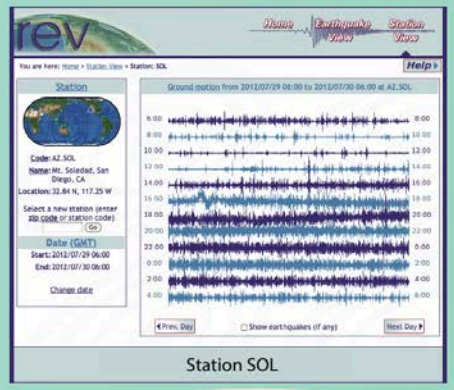


Station Z40A

- [x] Time of day histograms show most detections are in the daytime.
- [x] Waveform data shows detections are likely not seismic.
- [x] Do not select this station for use in our initial beta-testing (i.e., detections likely non-seismic).
- [ ] Select this station for use in our initial beta-testing (i.e., detections likely seismic).

Traffic

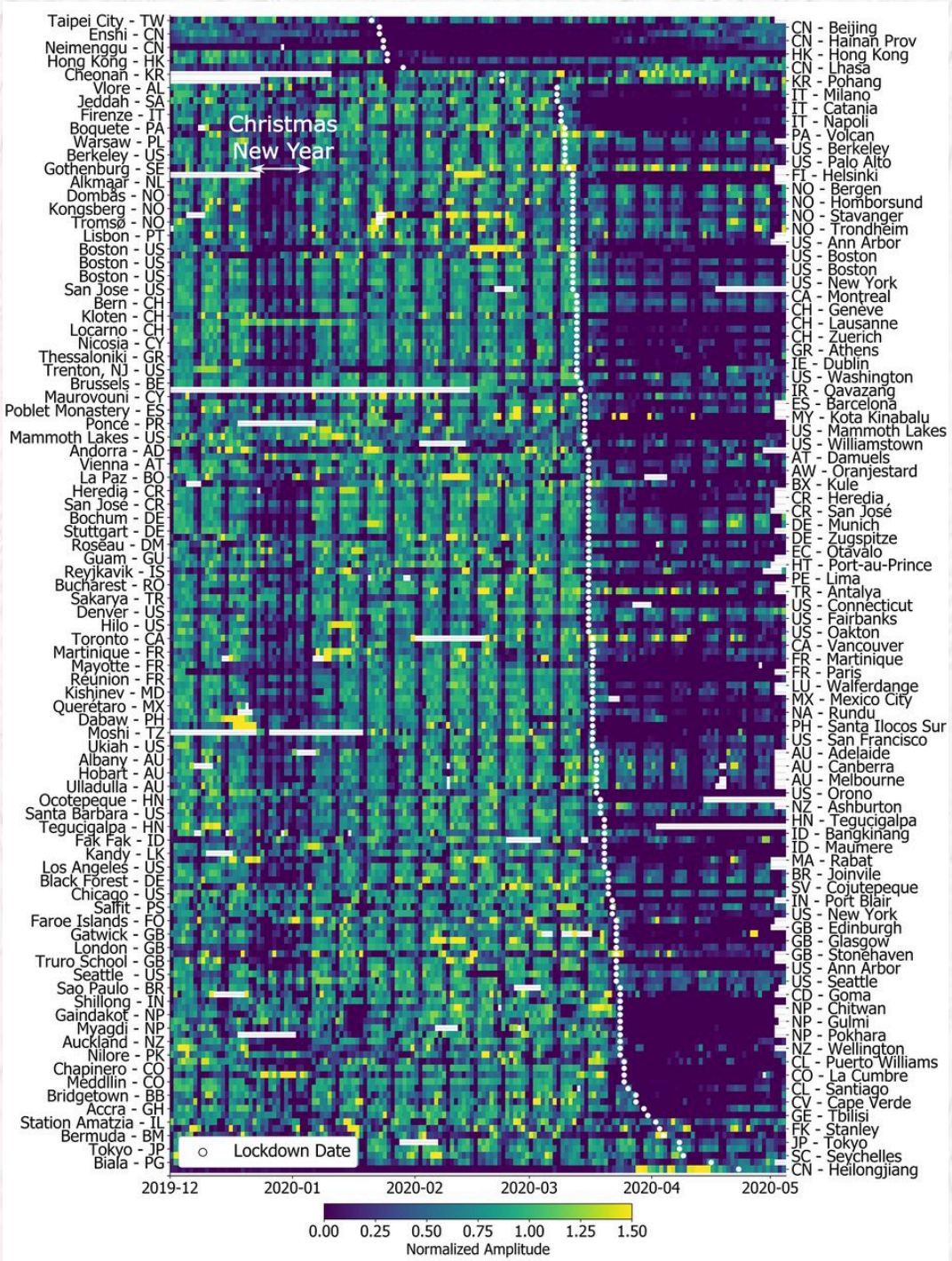




Station SOL

- [ ] Time of day histograms show most detections are in the daytime.
- [ ] Waveform data shows detections are likely not seismic.
- [x] Do not select this station for use in our initial beta-testing (i.e., detections likely non-seismic).
- [ ] Select this station for use in our initial beta-testing (i.e., detections likely seismic).

Good News: Our detection algorithm correctly ignores signals caused by traffic as evidenced by the minimal detections during the daytime at station SOL.



Global quieting of high-frequency seismic noise due to COVID-19 pandemic lockdown measures

Lecocq et al. (2020)
Science Magazine July 2020

Back to Utah and Earthquakes and Pandemics

Beginning March 16

- University is restricted essentially closed—needed permission to go into building
- All UUSS staff teleworking
- All non-essential university travel restricted (travel off campus is considered university travel)

Plans in Place

- Continuity of Operations Planning: redundant data collection sites, operational exercises for work from home and responding to earthquakes
- Established a Google Hangouts for communication
- Limited equipment moved to staff residences—field trucks and some computers [had initially planned to be out for a couple of weeks—UUSS still teleworking]

I hope everyone had a good day today. I know it's stressful and things are going to be difficult, but I have so much confidence in all of you that I just know we are going to be OK, even if we catch a big earthquake. Keith Koper

Mar 17, 8:26 PM

Cheers to that!

James Holt • Mar 17, 8:27 PM

We just got busyy!

John Mark • Mar 18, 7:10 AM OT: 7:09:32 AM

Keith!!!!

Cindi • Mar 18, 7:10 AM

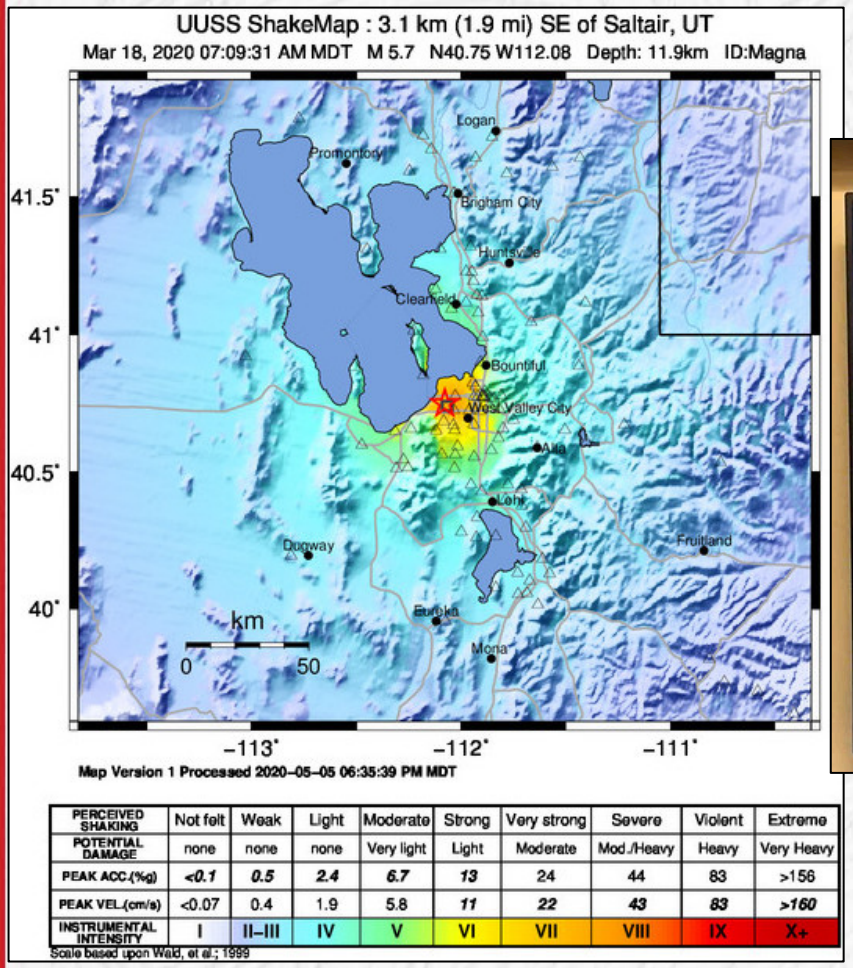
!!!!!!

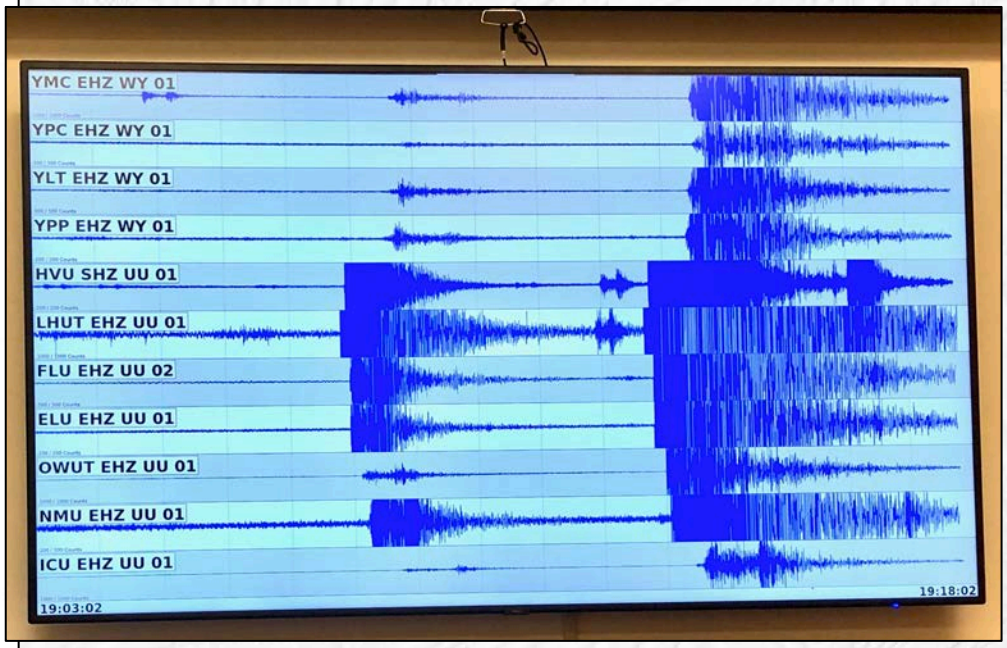
Maria • Mar 18, 7:10 AM

Keith you jinxed us!

Jamie • Mar 18, 7:10 AM

Because of COVID-19, UUSS entered work-from-home (WFH) mode in the middle of the day on Monday, March 16. Our first full WFH day was Tuesday March 17.





Magnitude M_w 5.7 earthquake at 7:09 AM on Wednesday, March 18, 2020

Largest earthquake in Utah since 1992

No serious injuries or fatalities, > $150M in damage estimates

Response During a Pandemic

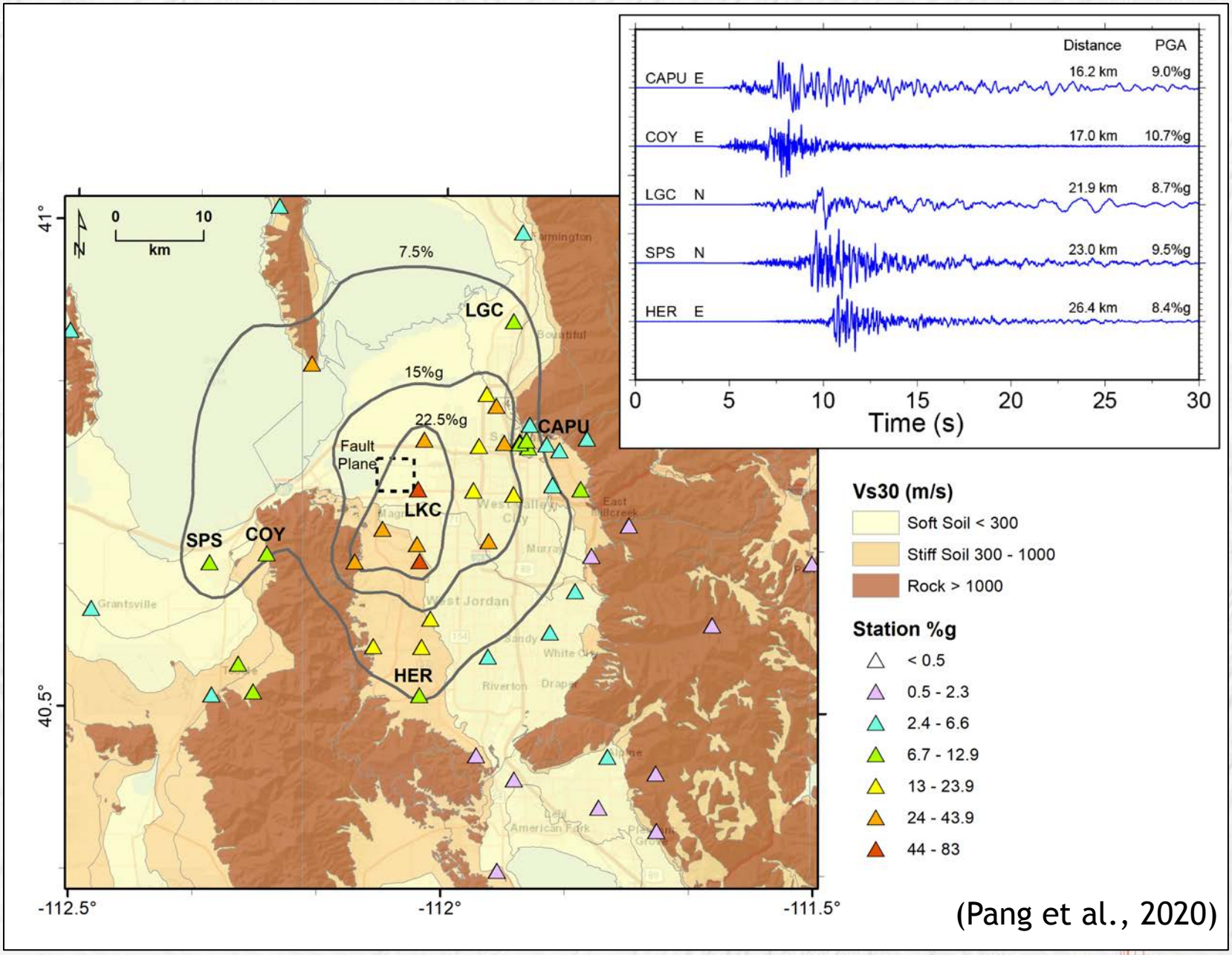
- Keith Koper took small staff to university public outreach
- Kristine Pankow coordinated with remainder of staff and various USGS groups from kitchen
- Tasked all duty seismologists to help triage automatic alarms in order to process largest events first
- Worked with State partners to get land access for aftershock deployments (State was closed—offices were not open)

Impacts on the Response

- Social media reported that M 9.0 imminent at noon
- Travel restrictions due to COVID and toxic plume release
- Browning building damaged and initially red tagged

. . .weather, accessing PPE type supplies, receiving shipments, and mountain lions

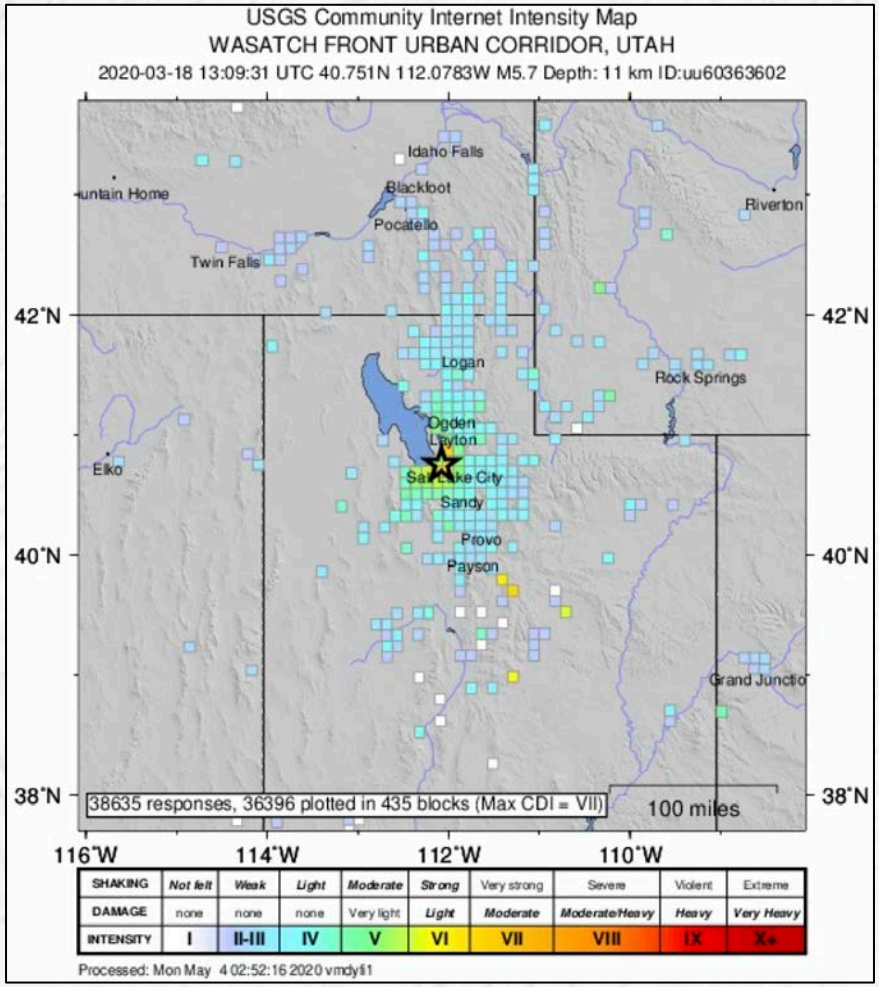
Felt Earthquakes and Damage



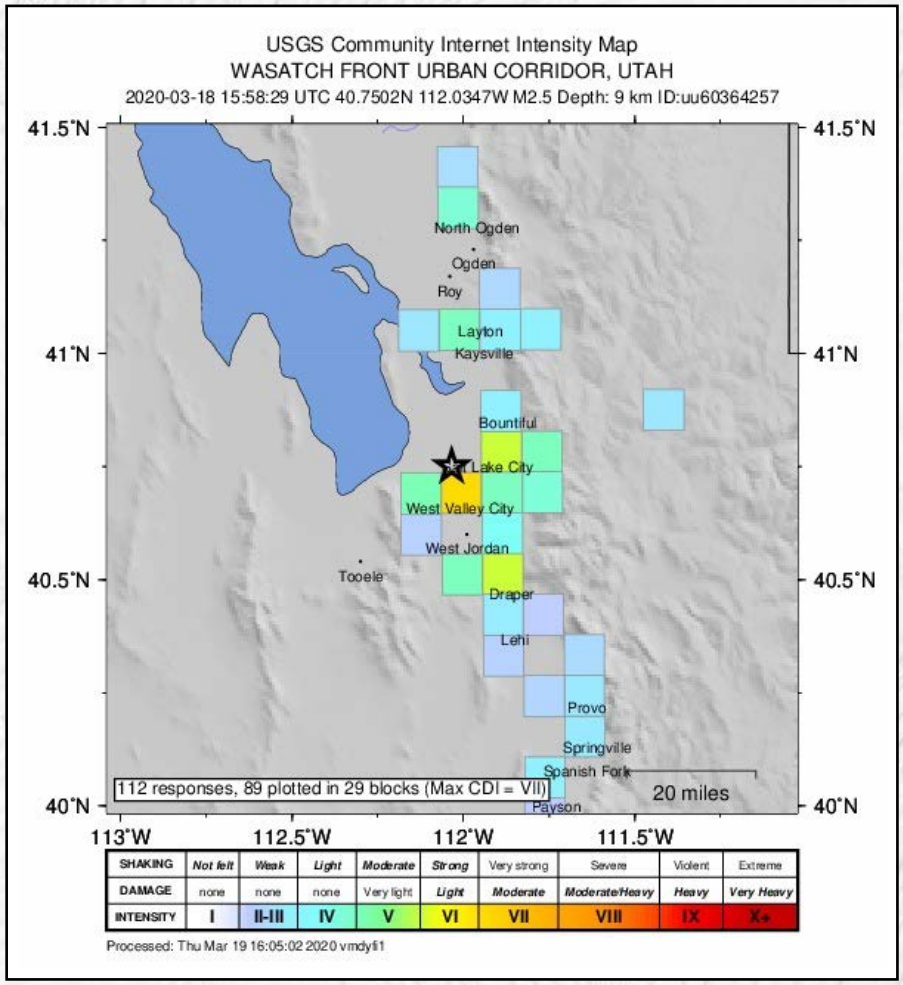
(Pang et al., 2020)

Max PGA of 54% g at station LKC.

M 5.7 Mainshock



M 2.5 Aftershock

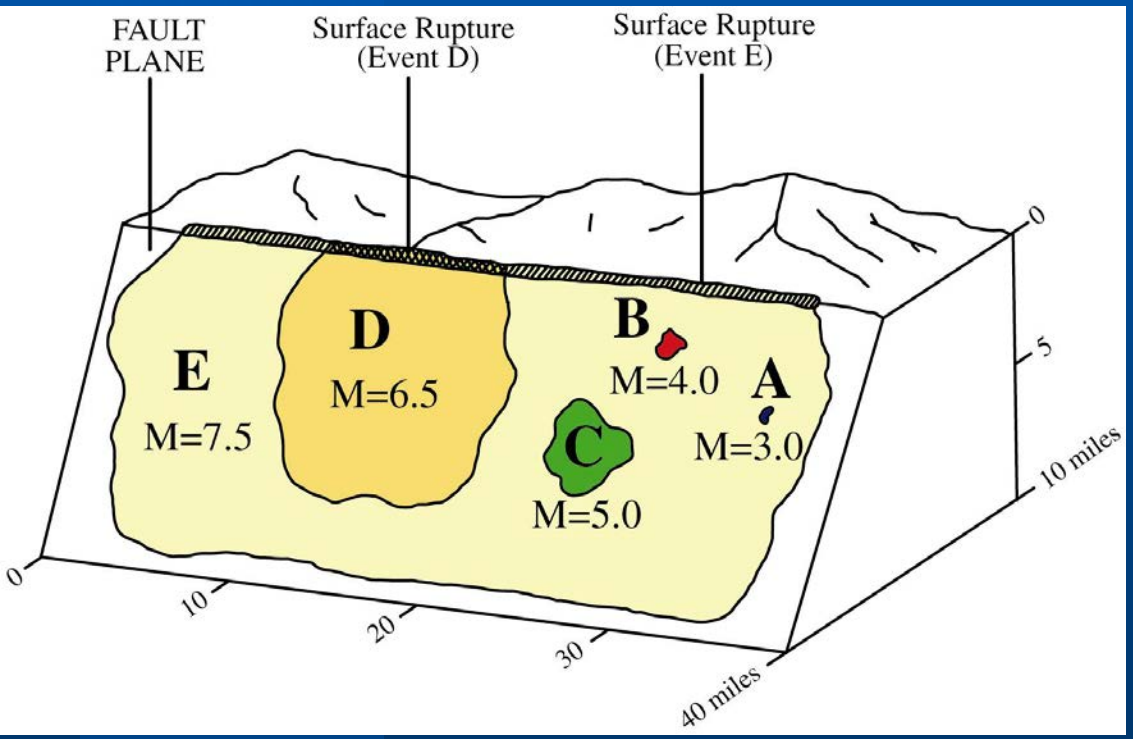



one


STANDARD MARKET

Why can't Utah have an M 9?

Fault Rupture and EQ Size



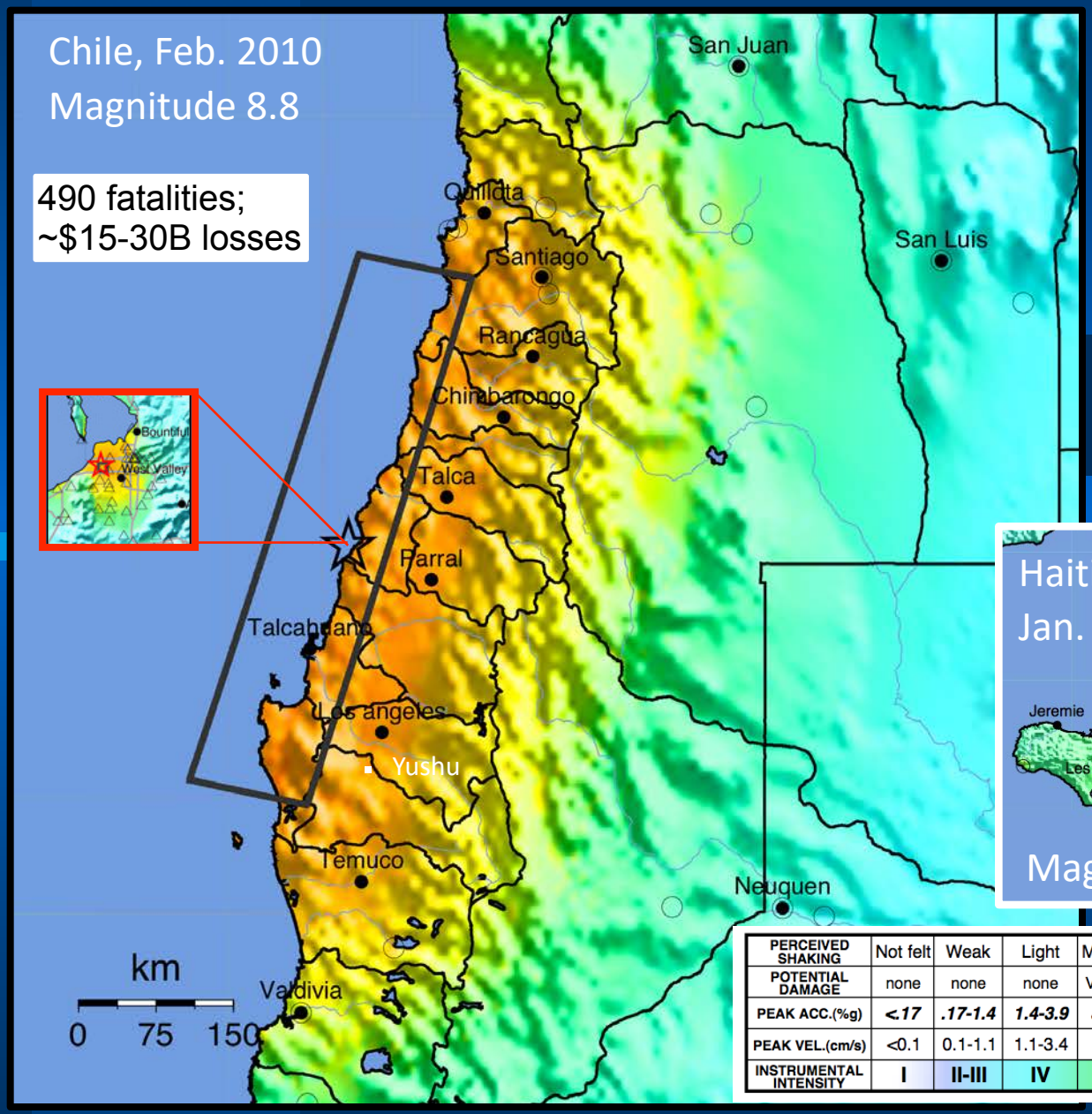
	Mag.	~ Area	~Slip*
A	3.0	0.1 mi^2	<< 1 in
B	4.0	0.4 mi^2	< 1 in
C	5.0	4 mi^2	3 in
D	6.5	60 mi^2	2 ft
E	7.5	400 mi^2	10 ft

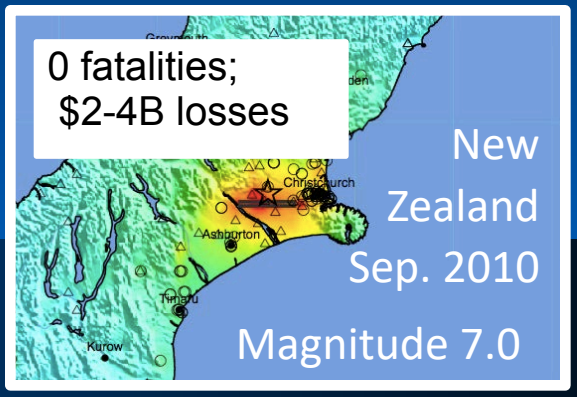
* Avg slip on rupture surface

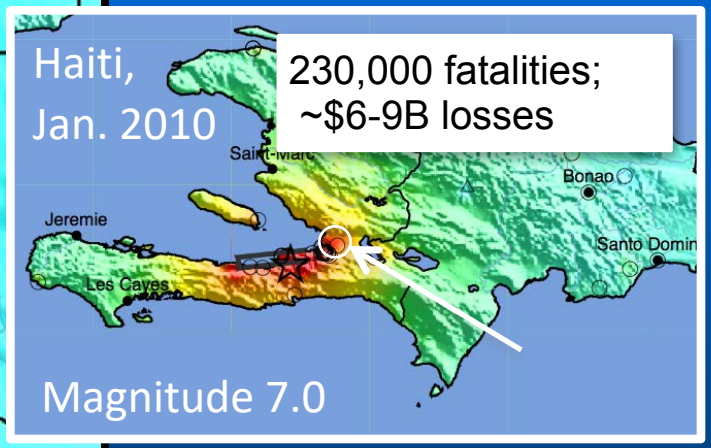
Radiated seismic energy increases ~ 30-fold as magnitude increases by 1.0 unit

USGS ShakeMap Estimated Shaking Intensities

[Same Map Scales!]

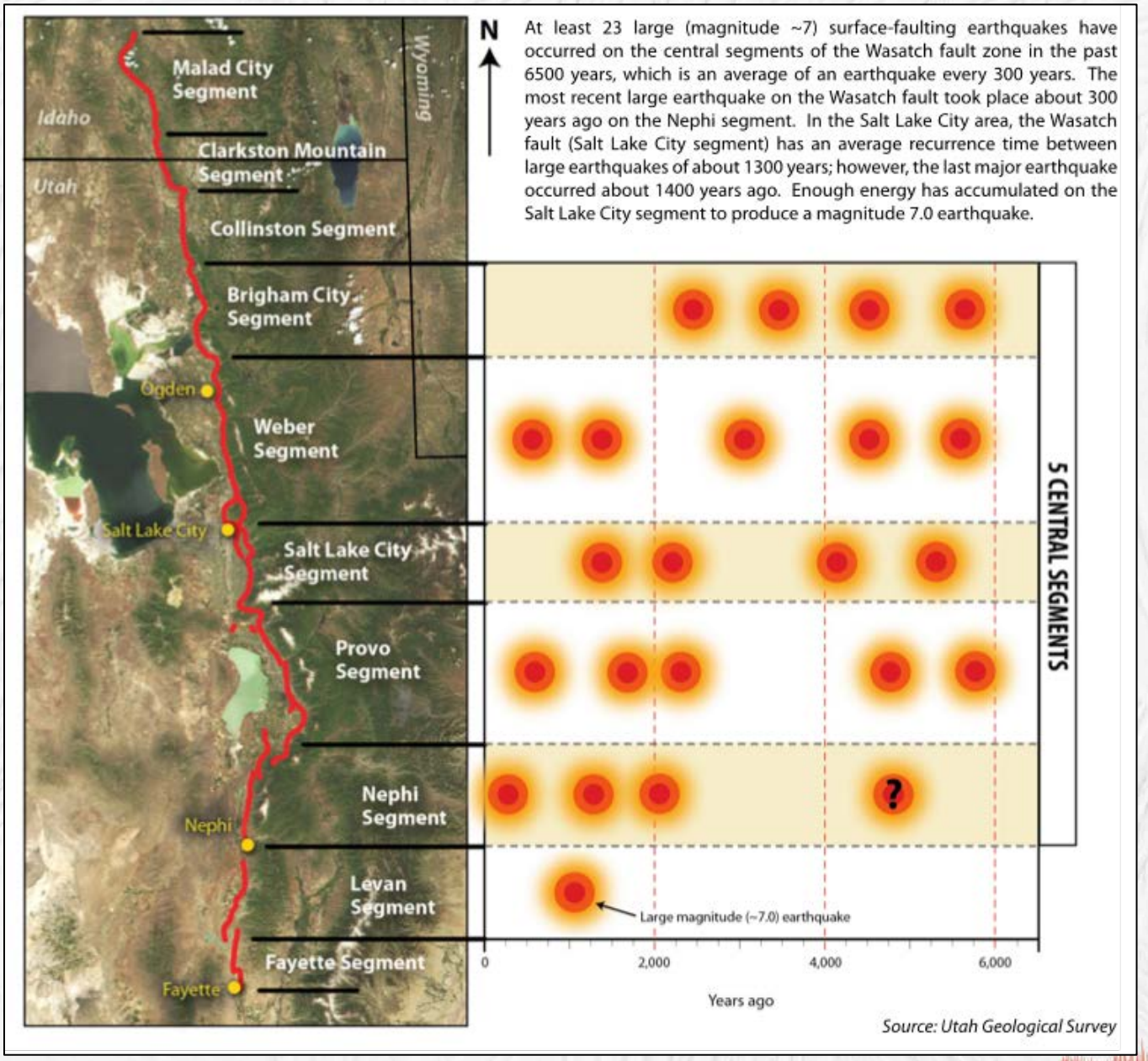






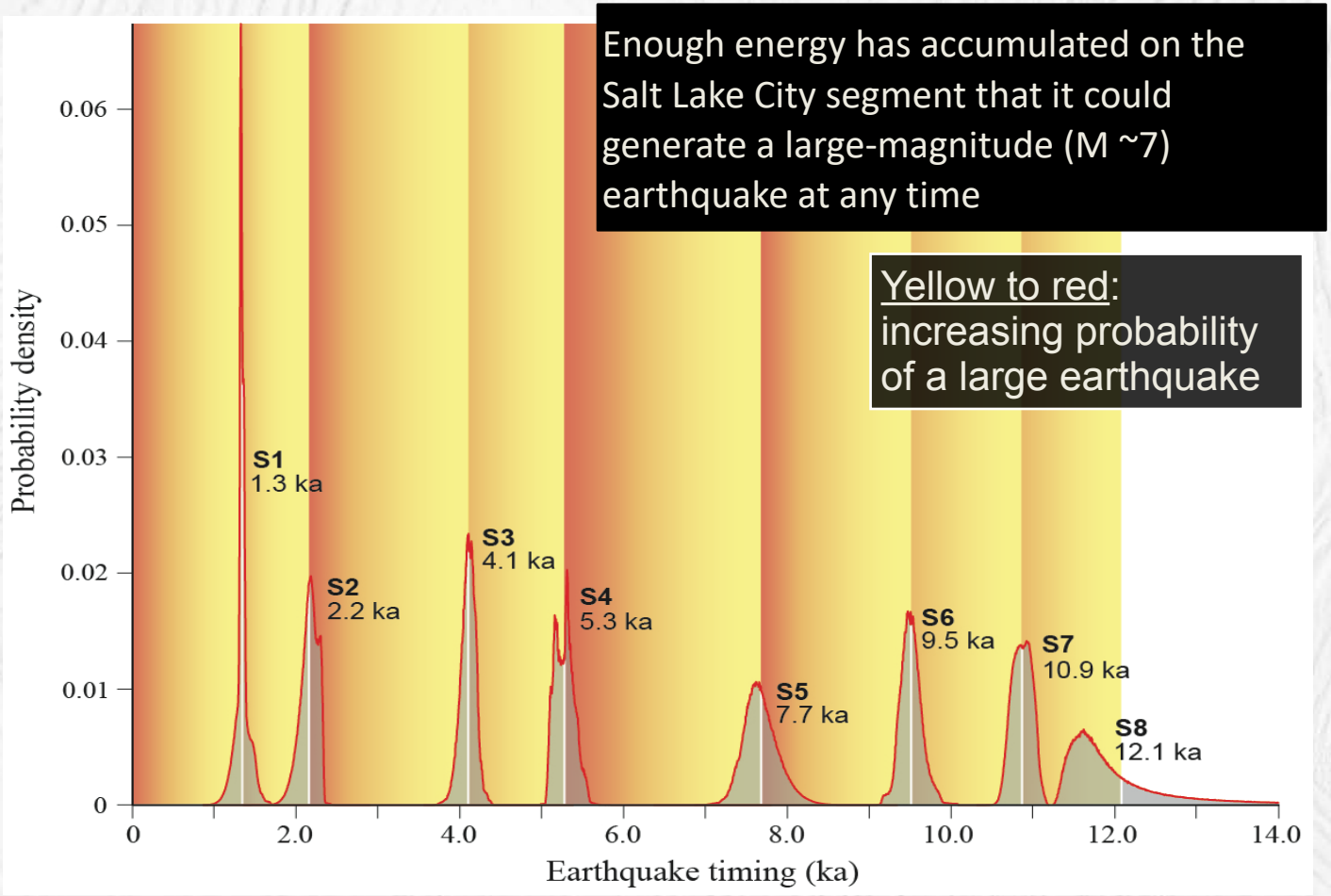
PERCEIVED SHAKING	Not felt	Weak	Light	Moderate	Strong	Very strong	Severe	Violent	Extreme
POTENTIAL DAMAGE	none	none	none	Very light	Light	Moderate	Moderate/Heavy	Heavy	Very Heavy
PEAK ACC.(%g)	*<.17*	*.17-1.4*	*1.4-3.9*	*3.9-9.2*	*9.2-18*	18-34	34-65	65-124	>124
PEAK VEL.(cm/s)	<0.1	0.1-1.1	1.1-3.4	3.4-8.1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

Was this the big one?

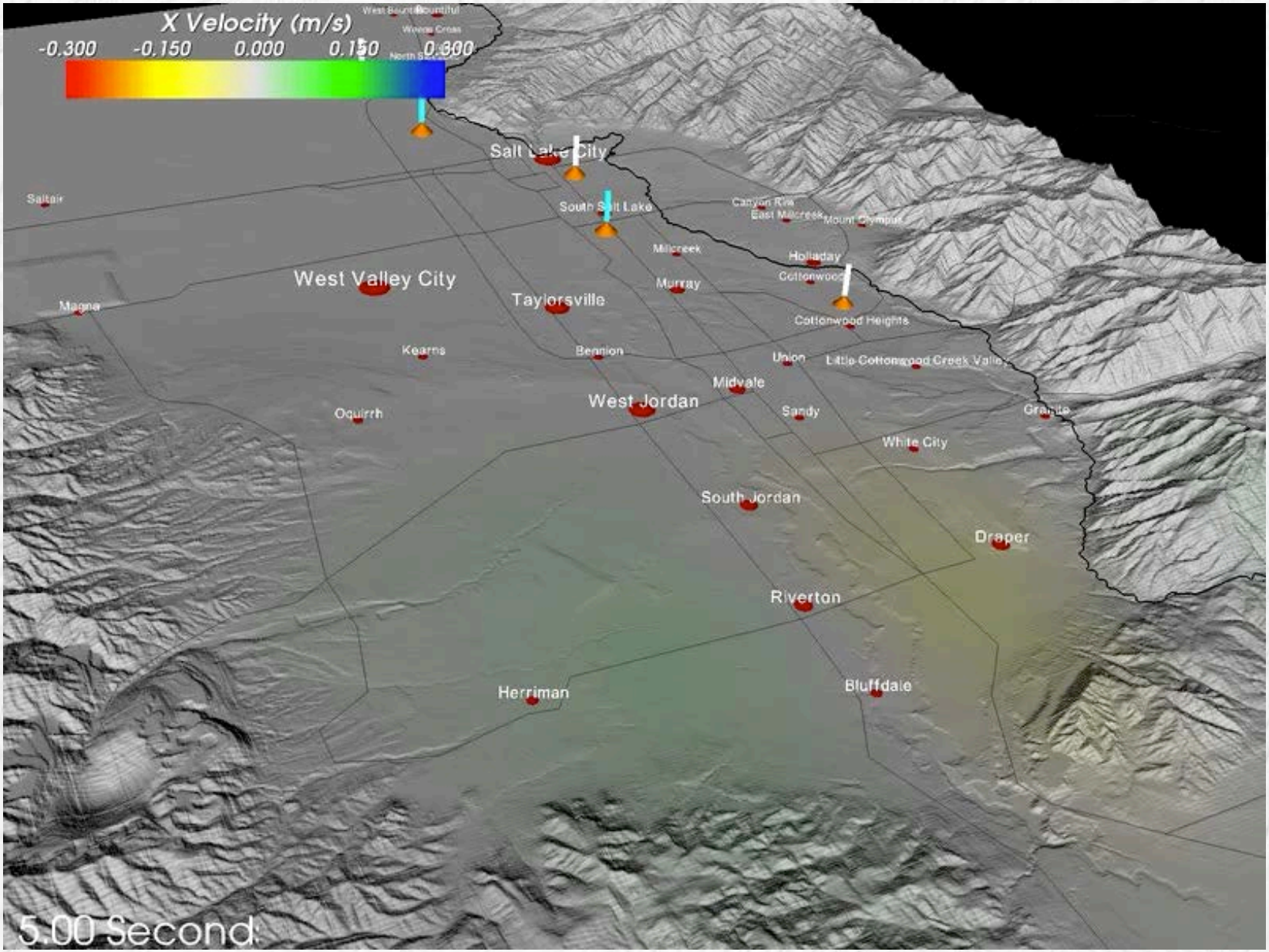


Paleoseismology from Utah Geological Survey

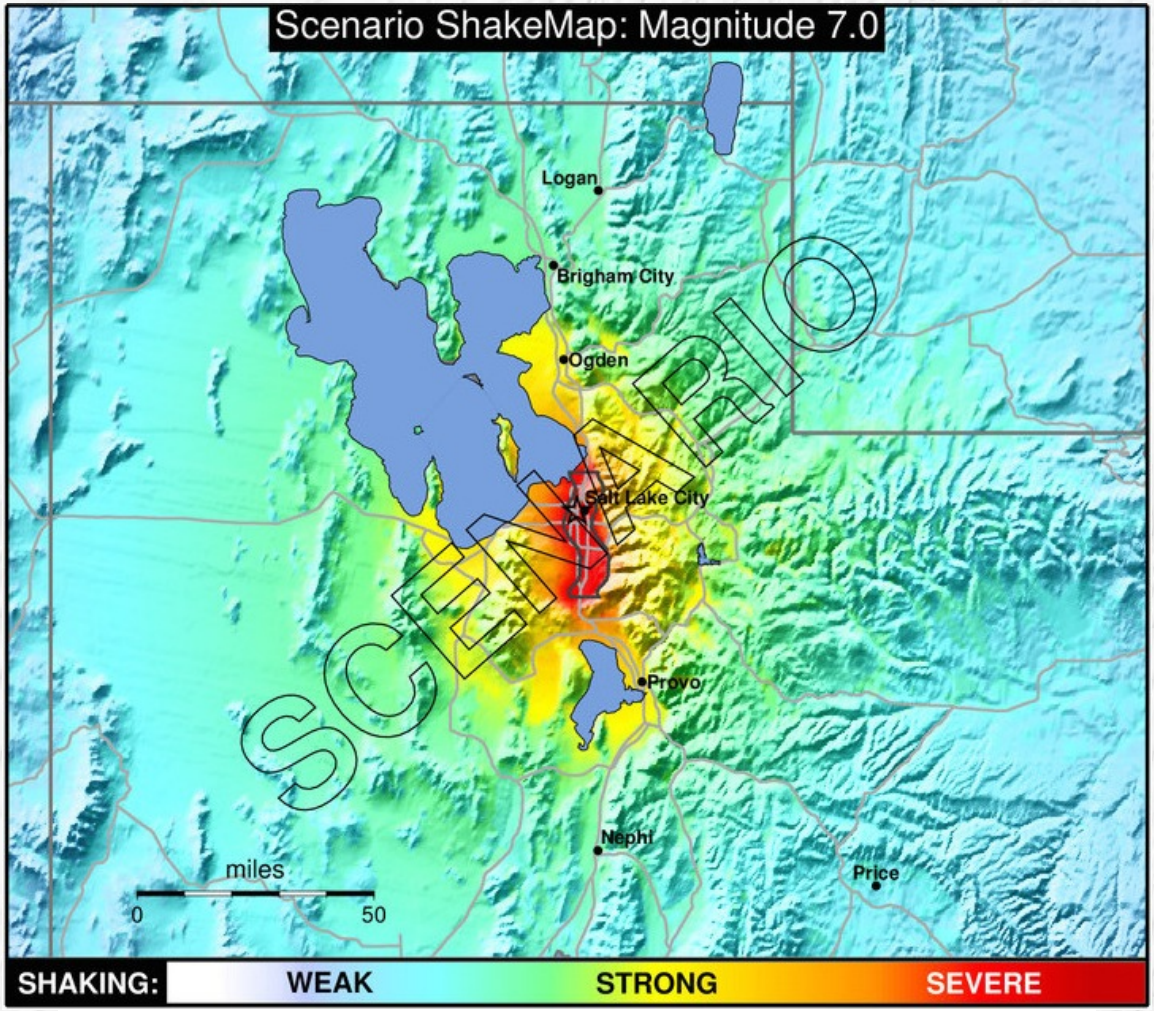
Salt Lake City Segment



Duross and others, UGS



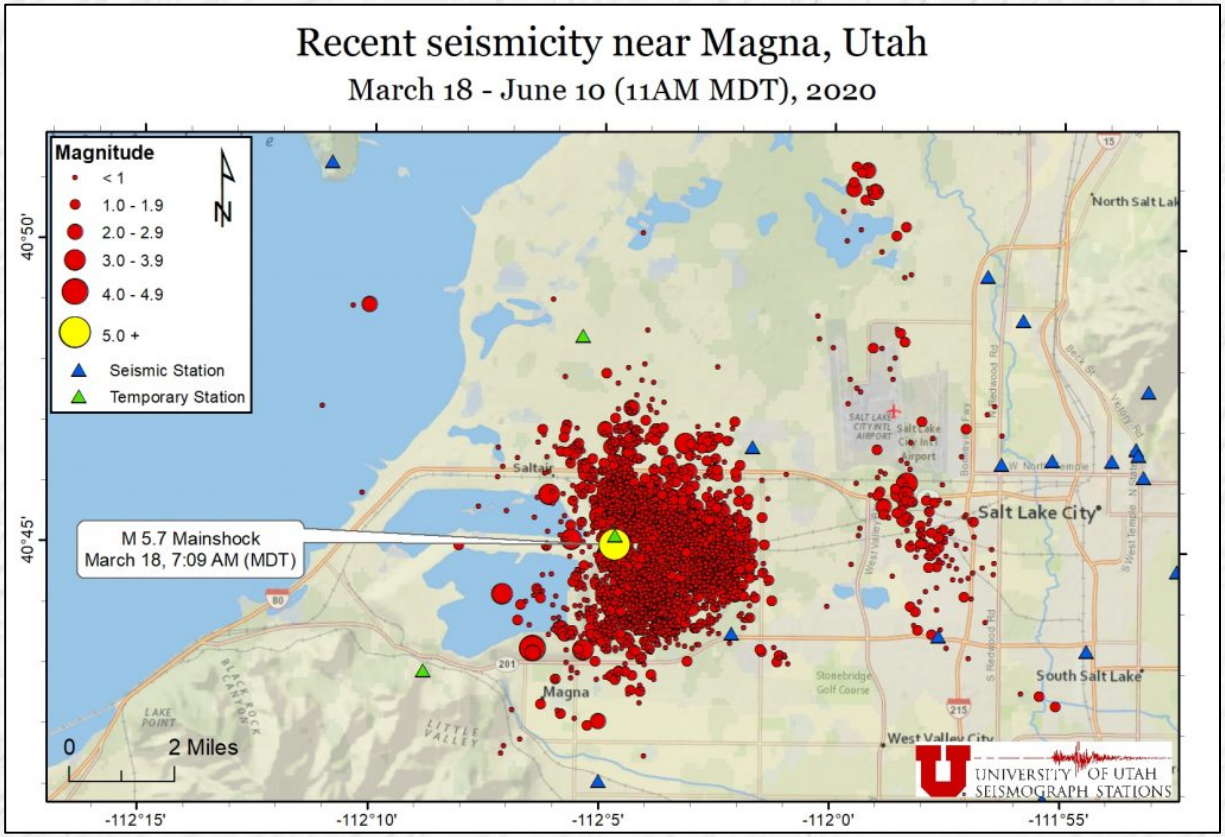
Roten et al. (2012)



PERCEIVED SHAKING	Not felt	Weak	Light	Moderate	Strong	Very strong	Severe	Violent	Extreme
POTENTIAL DAMAGE	none	none	none	Very light	Light	Moderate	Mod./Heavy	Heavy	Very Heavy
PEAK ACC.(%g)	*<0.1*	*0.5*	*2.4*	*6.7*	*13*	24	44	83	>156
PEAK VEL.(cm/s)	<0.07	0.4	1.9	5.8	*11*	*22*	*43*	*83*	*>160*
INSTRUMENTAL INTENSITY	I	II–III	IV	V	VI	VII	VIII	IX	X+

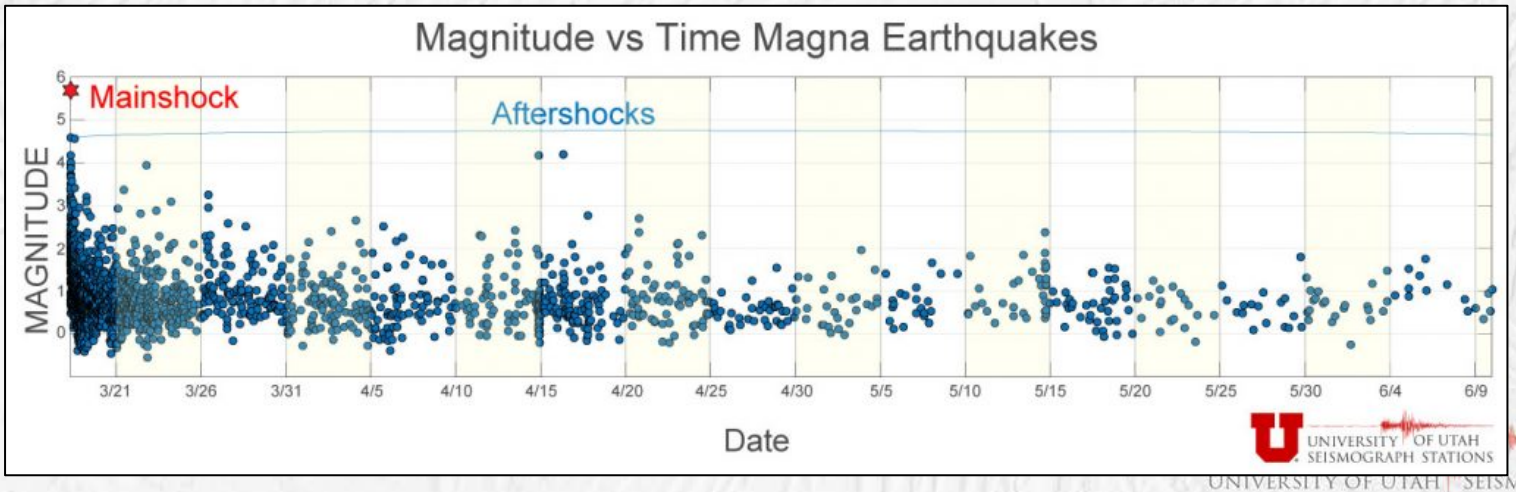
Scale based upon Wald, et al.; 1999

Mainshock and Aftershock (Foreshock)

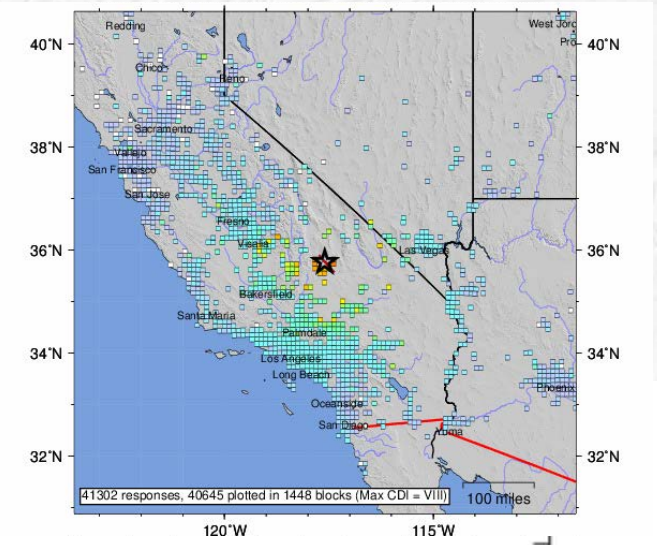


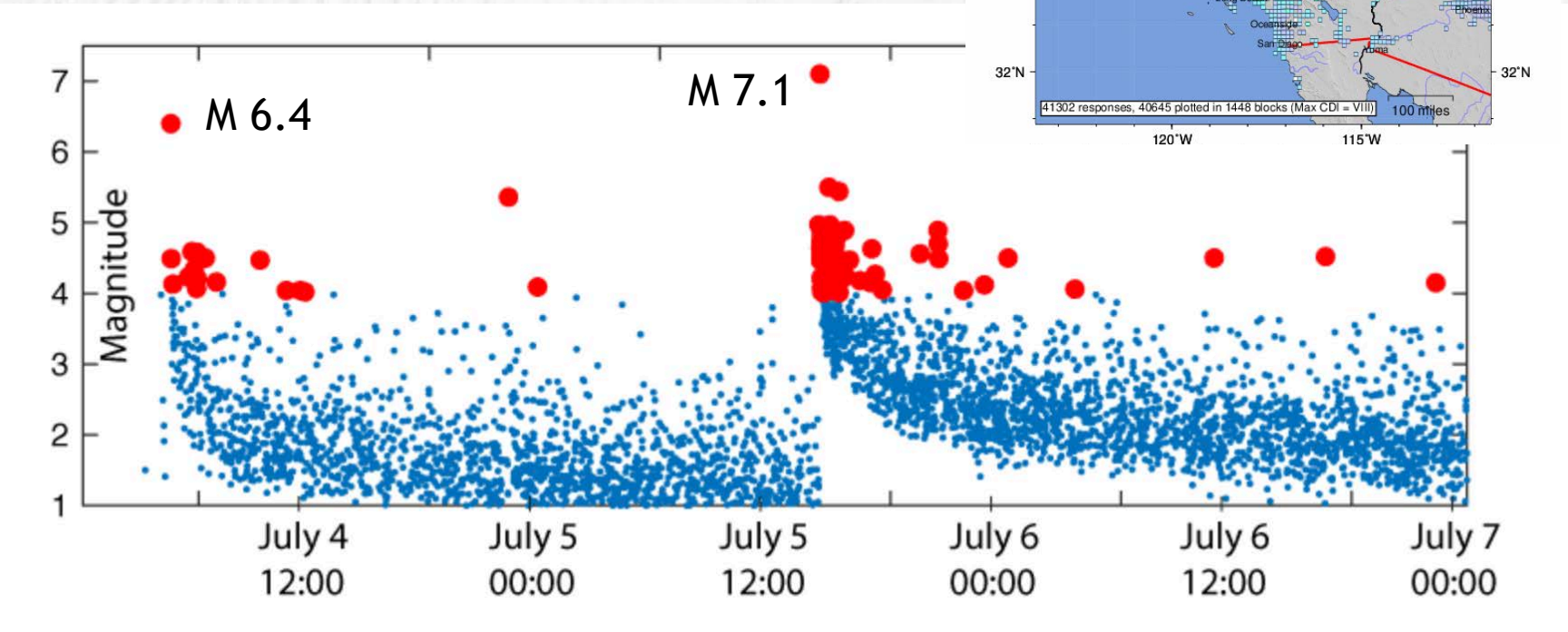
2,289 total

6 with M>4
34 with 3<M<4
146 with 2<M<3



2019 Ridgecrest, CA Earthquake Sequence





Mainshock ——Aftershocks————————-

Foreshocks ————————————————-Mainshock———Aftershocks————-

Chance the M 5.7 was a Foreshock

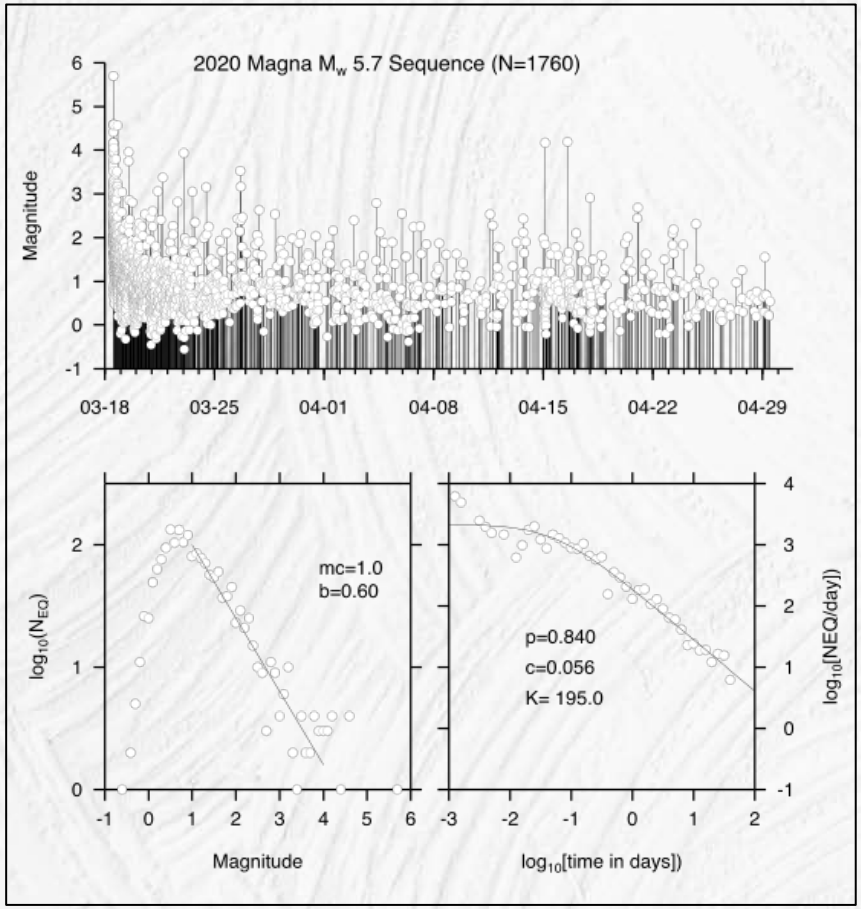
- ~5% chance that a larger (even by 0.1 units) will occur in 5 to 6 days following mainshocks
- Magnitudes 1 to 2 units larger much smaller than 5% chance

Aftershock Probabilities

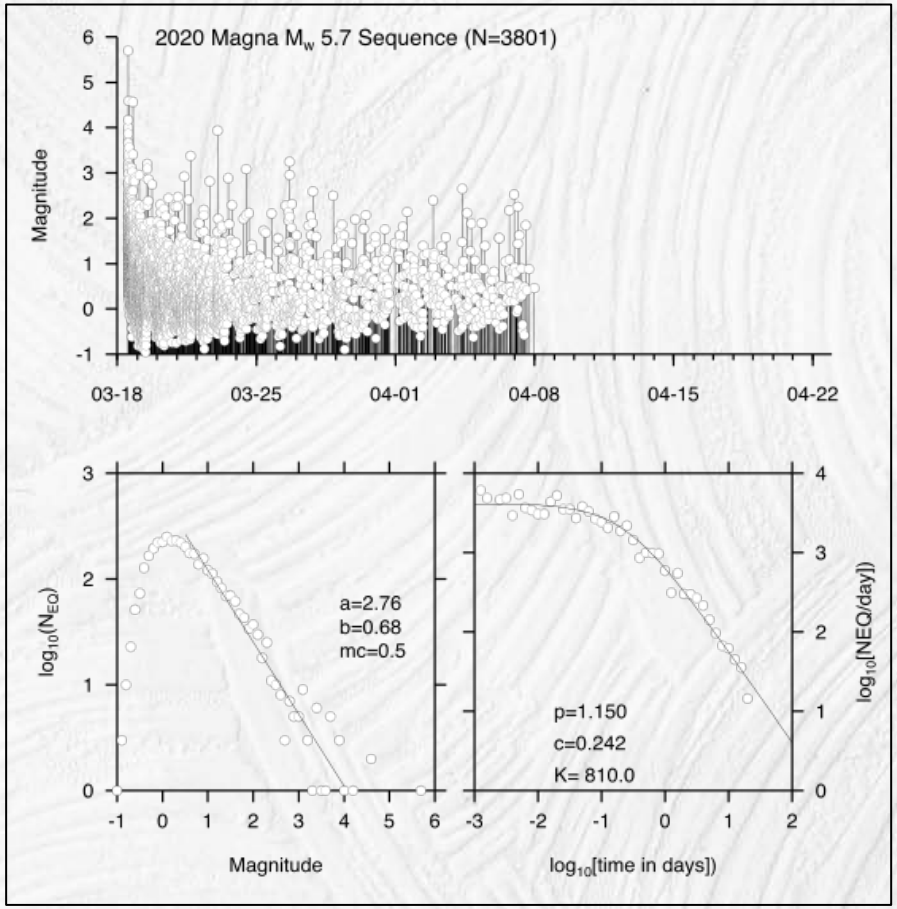
2020-03-18 13:39:35 Generic Model		
Magnitude	1 Day	1 Week
M≥3	0-149 (30)	0-235 (33)
M≥5	0-3 (0)	0-3 (0)
2020-03-18 19:19:32 Bayesian Model		
Magnitude	1 Day	1 Week
M≥3	0-21 (2)	2-43 (5)
M≥5	0-2 (0)	0-2 (0)
2020-03-20 21:50:20 Sequence Specific Model		
Magnitude	1 Day	1 Week
M≥3	0-2 (1)	0-3 (4)
M≥5	0	0

What did we learn and what's next?

Standard Catalog

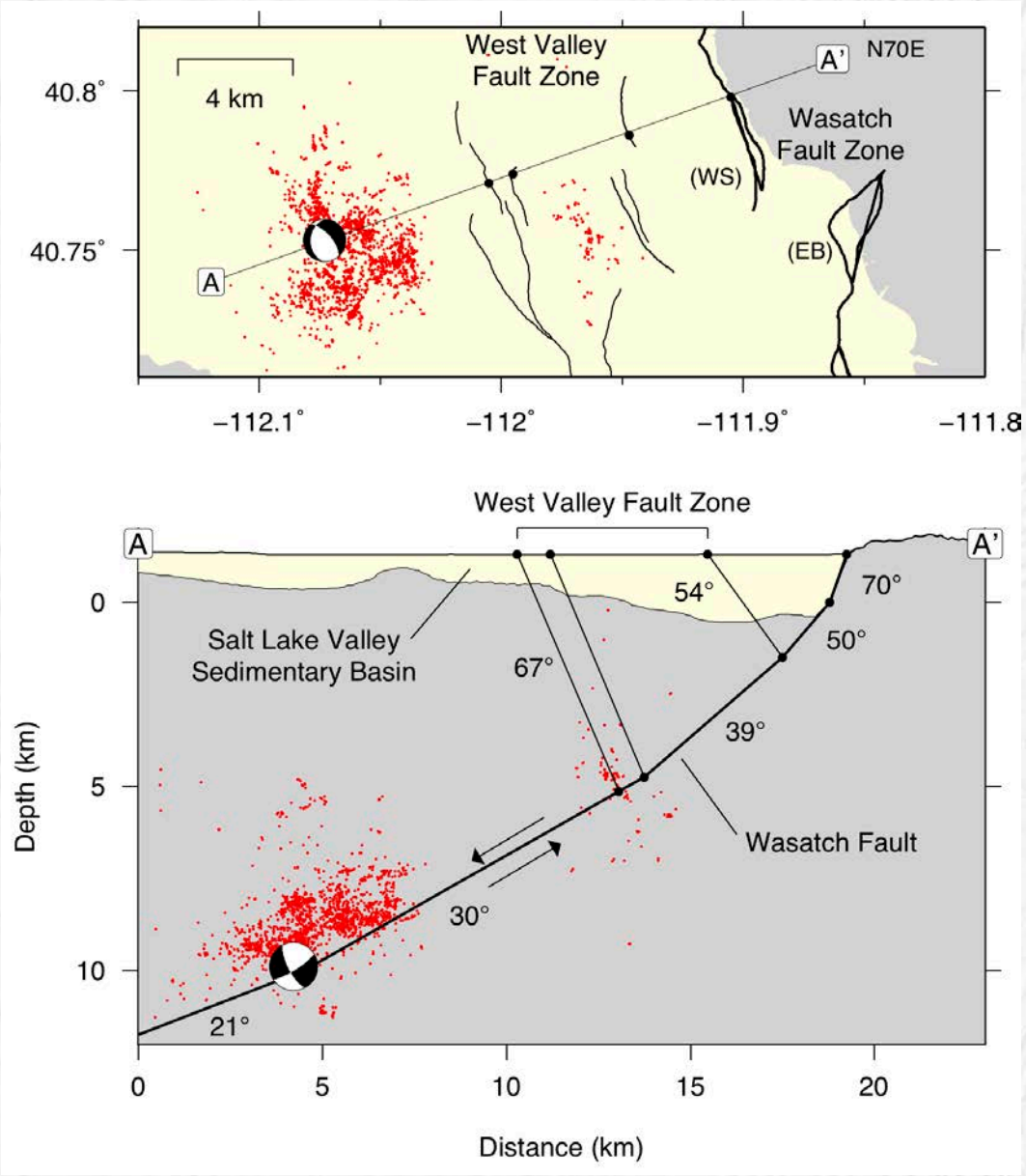


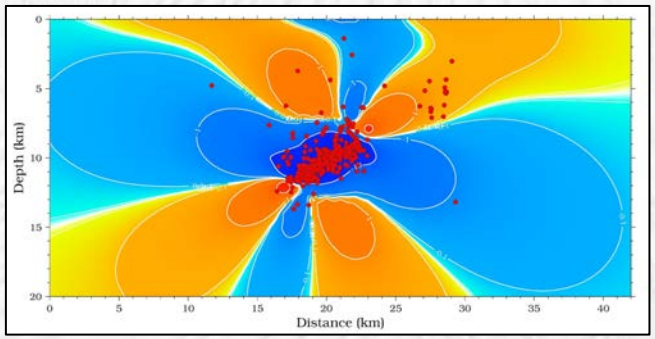
Enhanced Catalog



Relatively low b-value, meaning a higher relative number of large aftershocks.

High-Precision Relocated Aftershocks

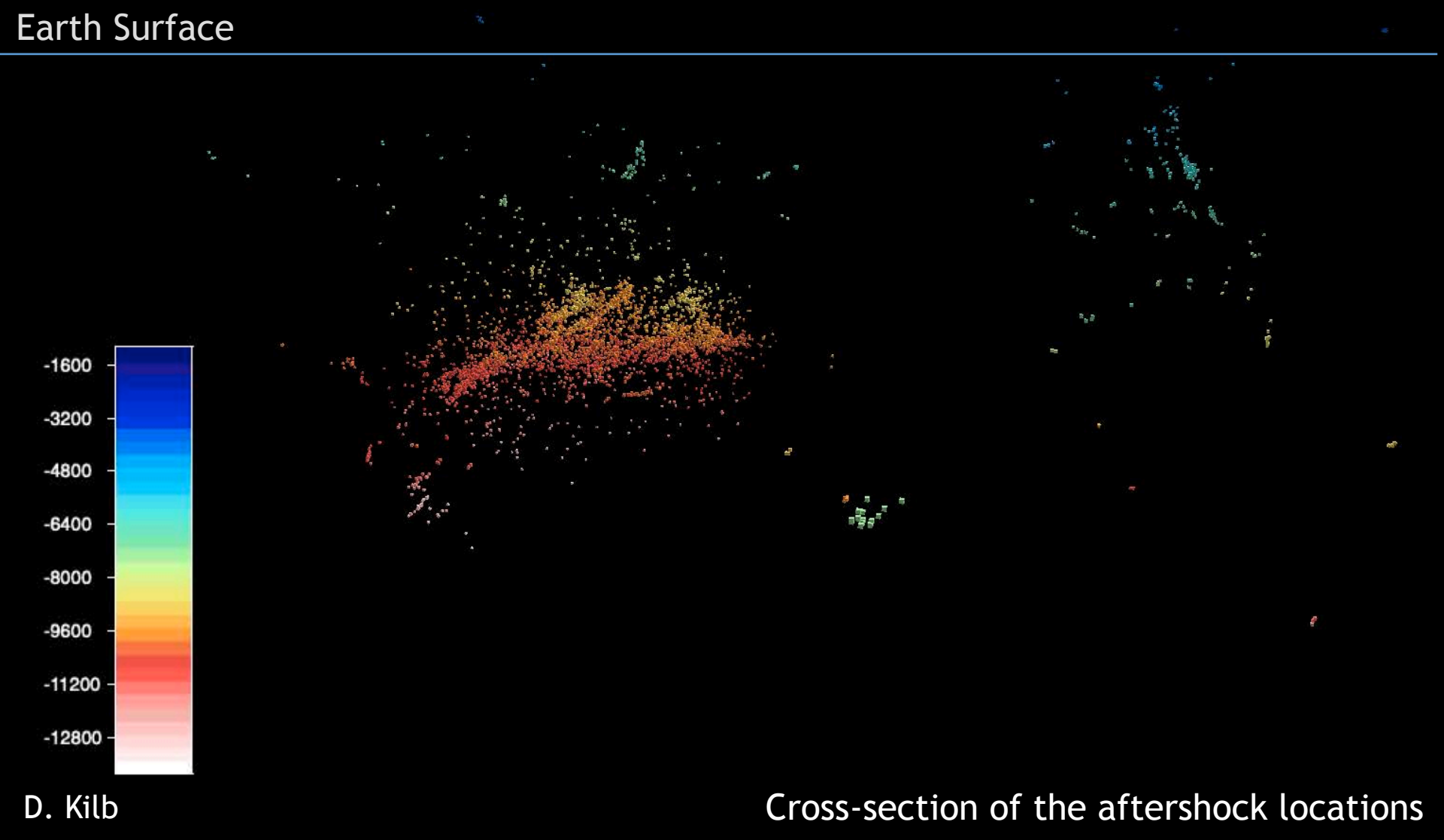




Stress changes consistent with triggering of aftershocks up-dip, beneath the airport.

(Pang et al., 2020)

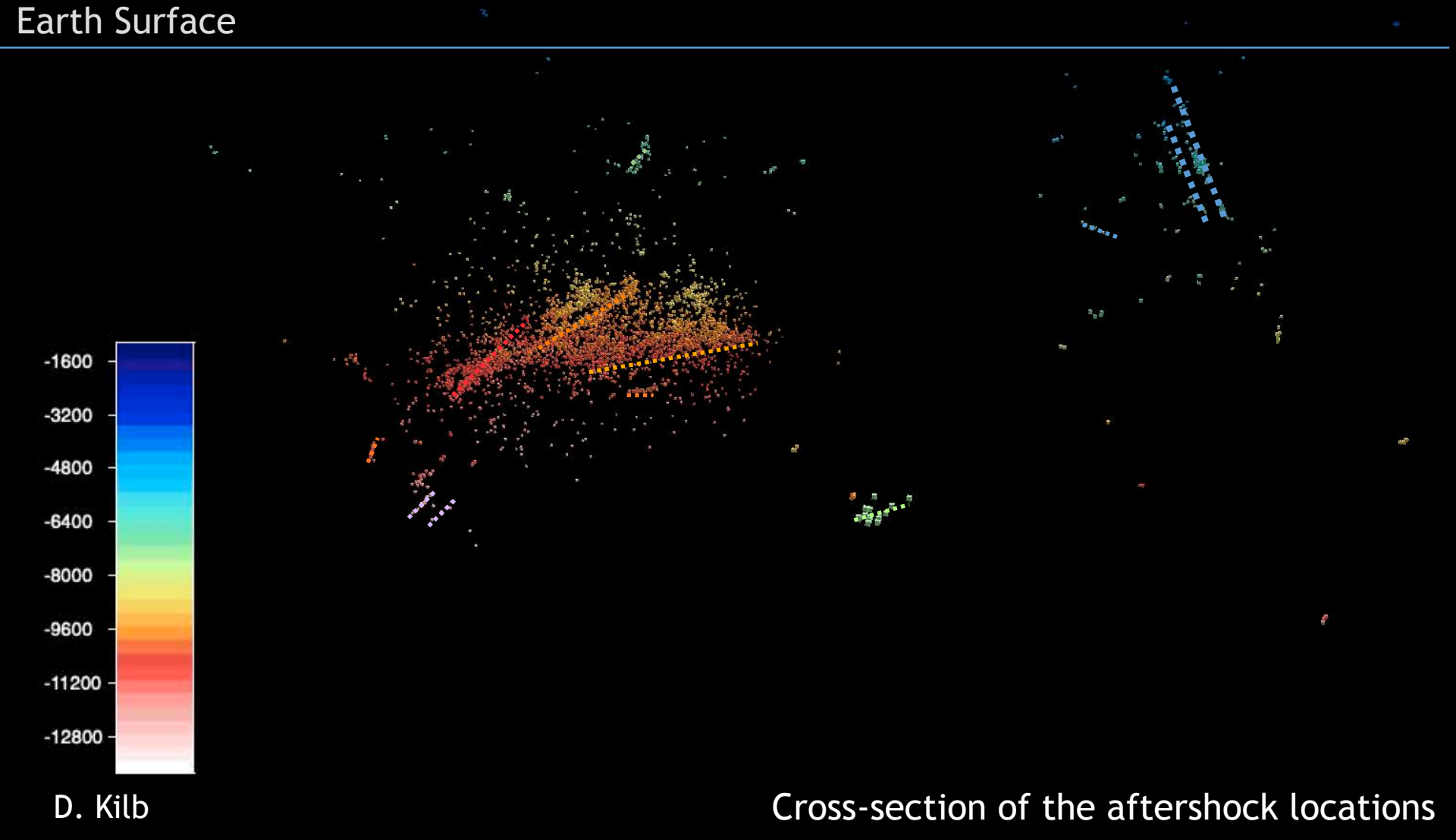
Colors represent earthquake depths

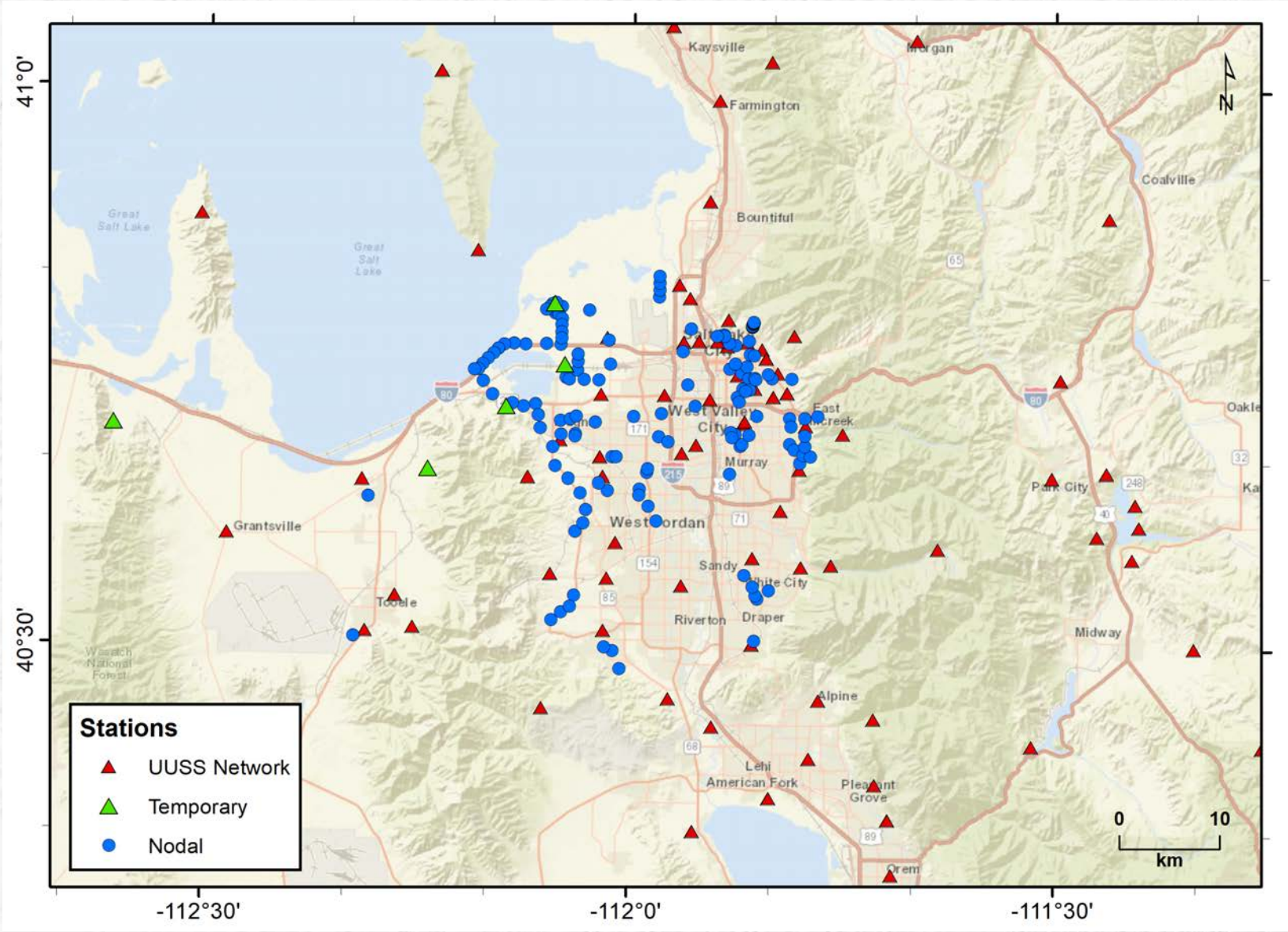


D. Kilb

Cross-section of the aftershock locations

Colors represent earthquake depths





UUSS added 5 telemetered stations (BB/SM) within 7 km of the mainshock,
and 180 non-telemetered geophones throughout the Salt Lake Valley.

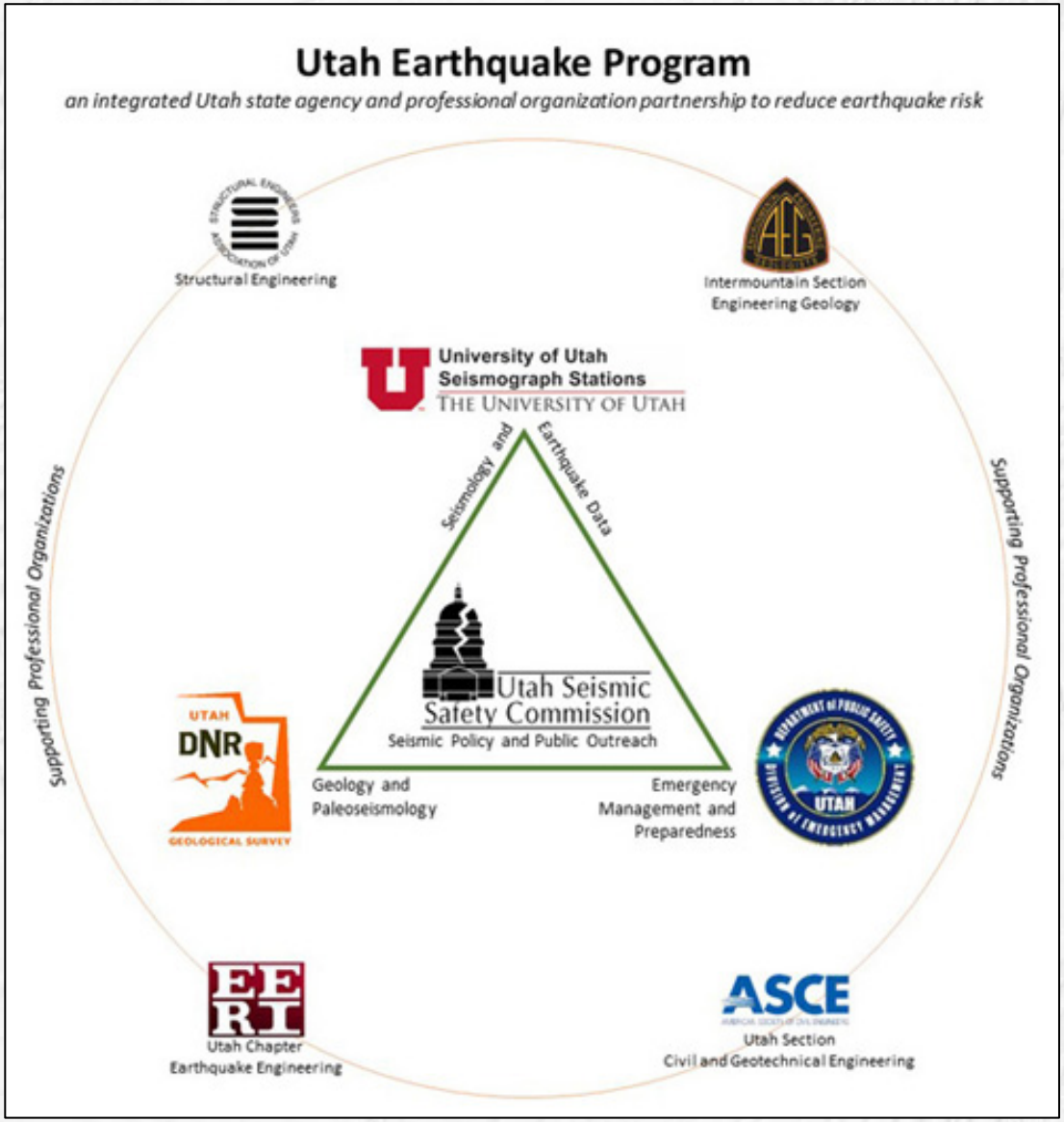
Summary

- The 18 March 2020 M_w 5.7 Magna earthquake was the largest earthquake ever recorded on the Wasatch fault, yet it was moderate sized; an M7 earthquake would release 90 times more energy.

- It relieved a small amount of stress on the northern edge of the Salt Lake City segment (SLCS) of the Wasatch fault; the SLCS is still capable of producing an M7 earthquake.

- The recurrence interval for large earthquakes (M>6.75) on the SLCS is thought to be 1,300-1,500 years; the last large event occurred about 1,400 years ago.

- The shallow dip of the fault system at depth supports a listric model for the SLCS and favors the idea that low-angle normal faults can fail in large earthquakes.



UUSS Staff

Amir Allam – research faculty
Ben Baker – research scientist
Bill Blycker – systems administrator
Relu Burlacu – network manager
Jamie Farrell – research faculty
Mark Hale – seismic analyst
Corey Hatch – field engineer
James Holt – post-doc
Keith Koper – director
Cindi Meier – business manager
Maria Mesimeri – post-doc
Wes O'Keefe – field technician
Kris Pankow – associate director
Arvind Parapuzha – field technician
Jim Pechmann – research faculty
Paul Roberson – seismic analyst
Jon Rusho – systems engineer
Becca Sumsion – comm. specialist
Katherine Whidden – research scientist