Science for Solutions: Linking DATA and DECISIONS

Seismic Hazard in Sacramento-San Joaquin River Delta using UCERF3 Source Models and NGA-West2 Ground Motion Models

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USGS seismic hazard mapping team

Mark Petersen

Sanaz Rezaeian

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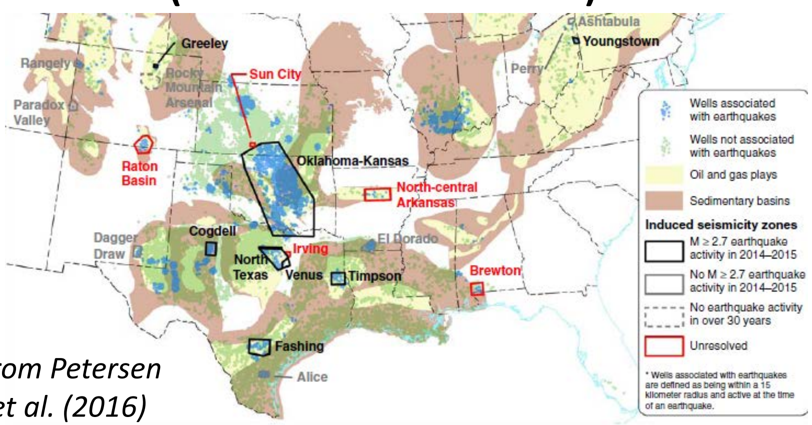
Earthquake hazard

Earthquakes
(Central Italy earthquake, Aug-Oct, 2016)

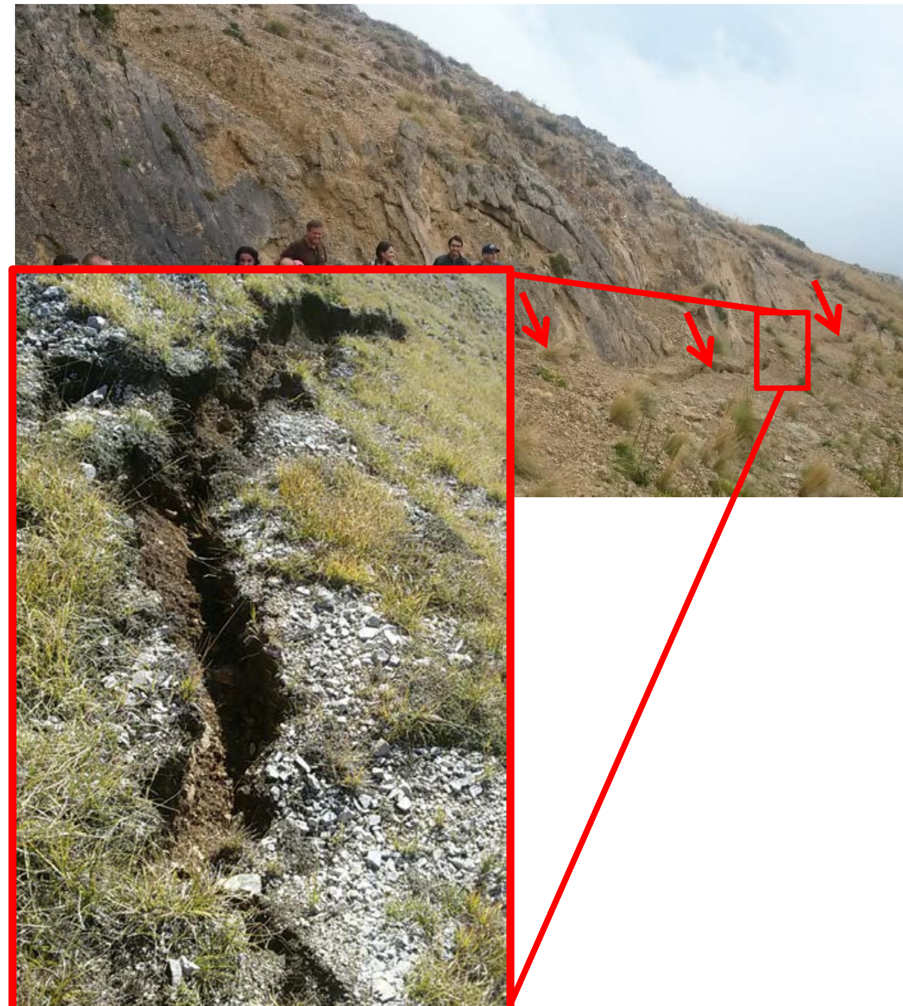
From GEER (2016)

Induced seismicity
(Central and Eastern US)



From Petersen et al. (2016)

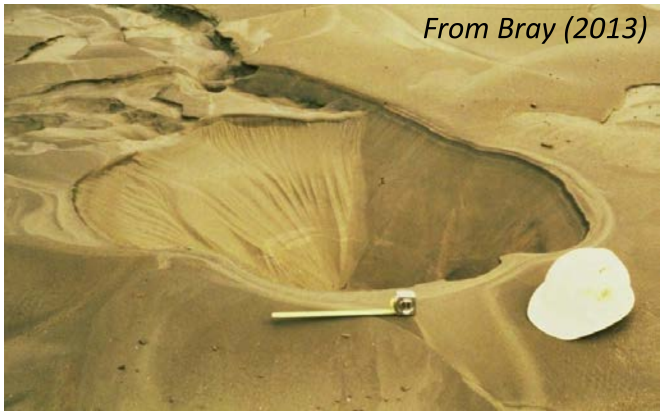
Fault surface ruptures
(Central Italy earthquake, Aug-Oct, 2016)



Earthquake hazard

Earthquake-induced liquefaction

(Loma Prieta, 1989)



From Bray (2013)

Earthquake-induced landslides

(El Salvador, 2001)

Ph. Edwin Harp

…And its effects (Kocaeli, 1999, Turkey)

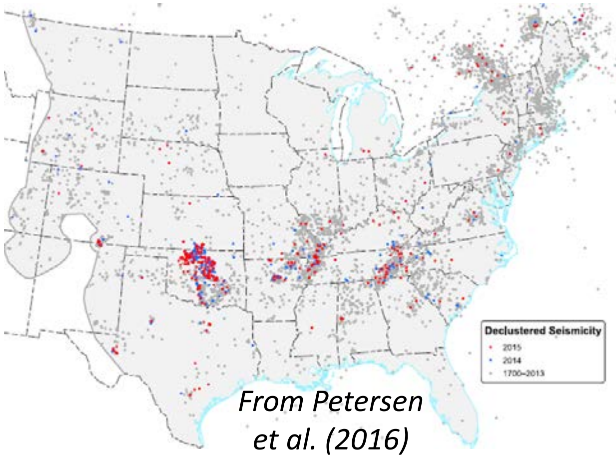
From Bray (2013)

Levee failures (Japan, 2007)

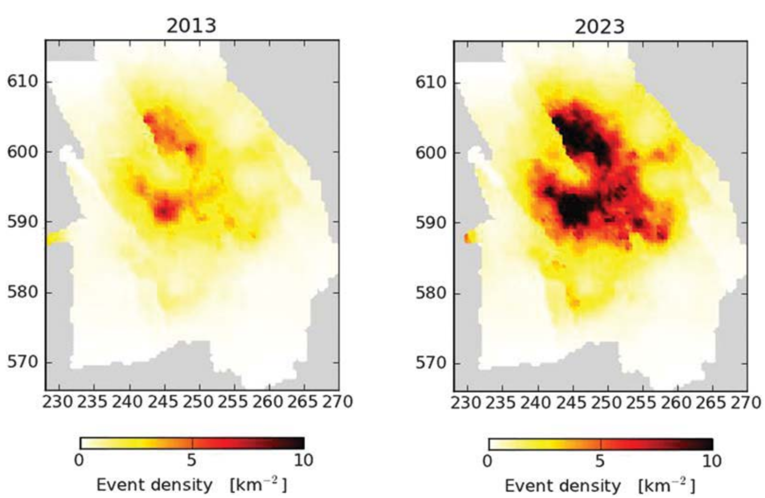
Shinano river levee system (Japan) – 2004 and 2007 earthquakes

New challenges

Increasing rate of induced seismicity



From Petersen et al. (2016)



From Bourne et al. (2015)

Impact of climate change

From The World bank (2016)

From VNK (2016)

Seismic vulnerability of the Delta Region's levee system

CALFED (2000) report on seismic vulnerability of the Delta levees: "**historical information** indicates that there has been **little damage to Delta levees caused by earthquakes**."

DRMS (2008) Delta Risk Management Strategy Project: "damaging **earthquakes are relatively rare, but high-consequence**, events that must be considered in any rational risk assessment for the Delta region."

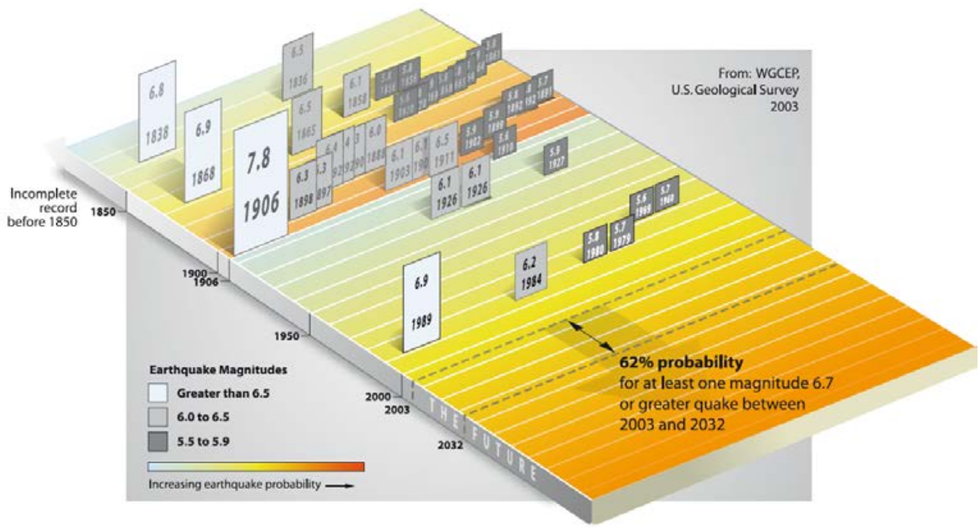
Deverel et al. (2016) discuss **possible indication of earthquake-related levee failures** after the **1906** San Francisco earthquake.

What if...

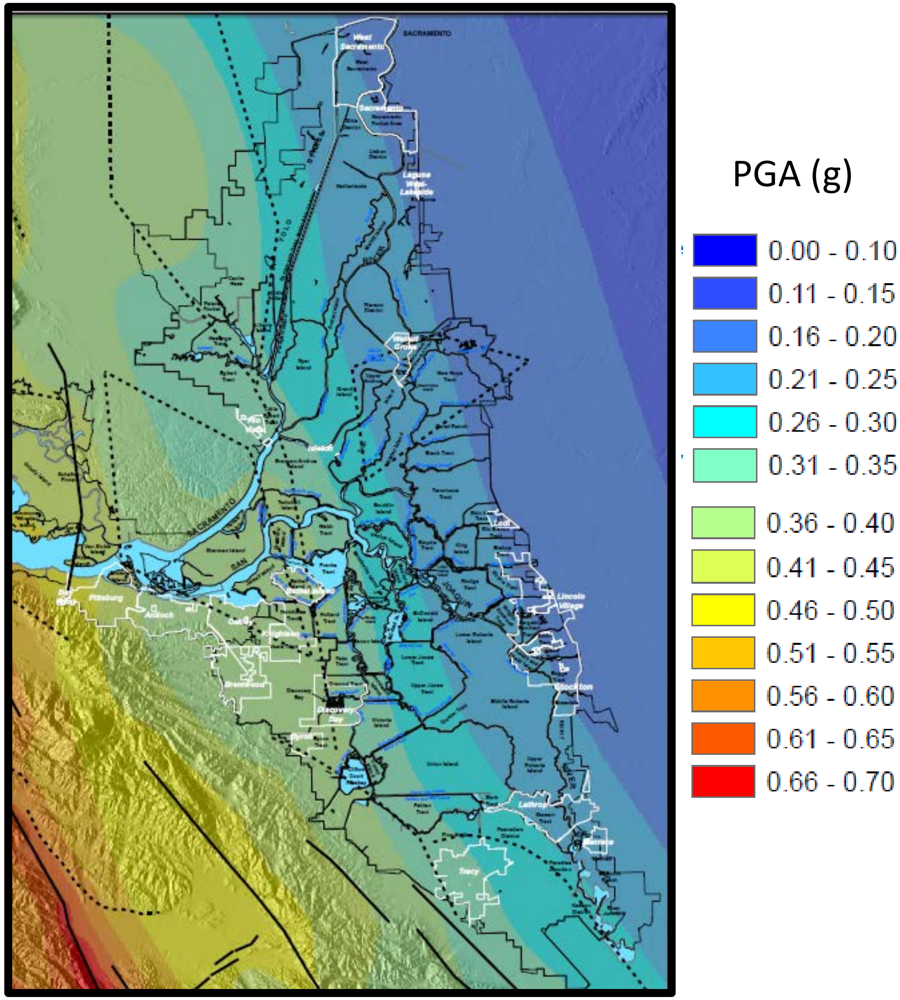
Multiple failures:
$15 billion total losses
Water delivery interrupted for 20 to 30 months

Previous studies

WGCEP (2003)



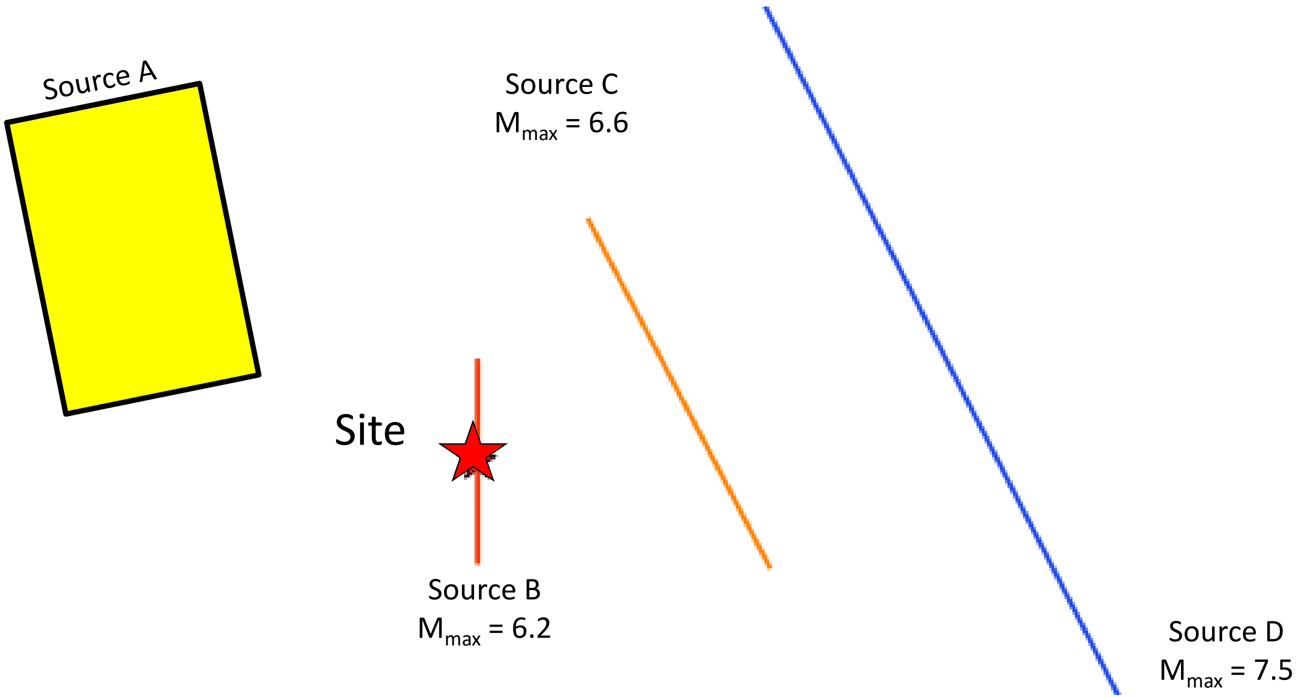
DRMS (2008; 2009)



Probabilistic Seismic Hazard Analysis (PSHA)

1. Earthquake sources characterization

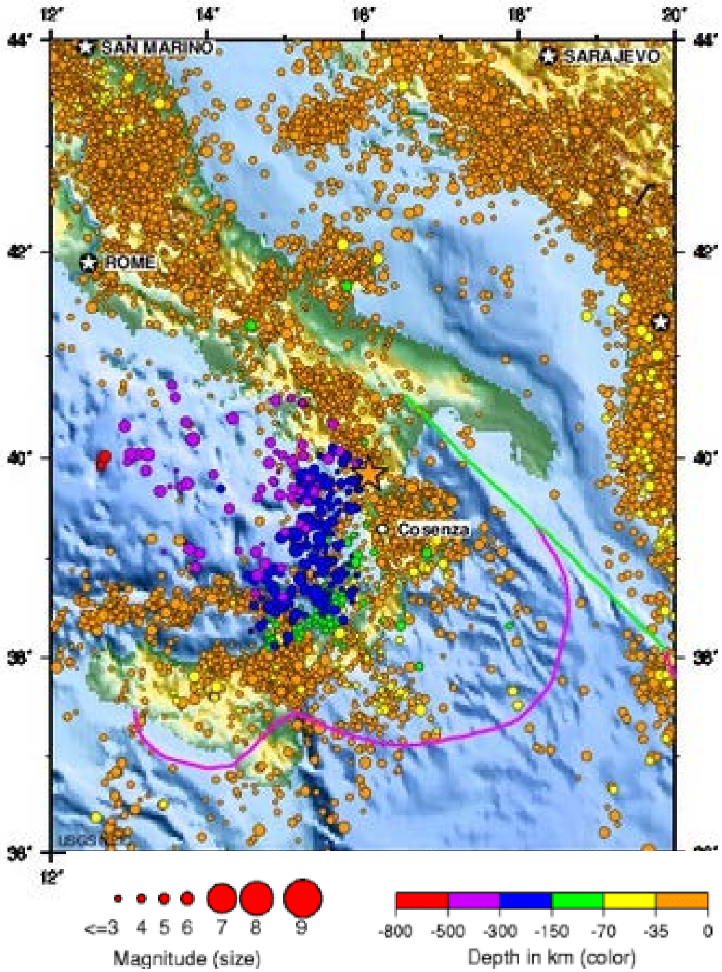
- *Finite faults*
- *Area sources and background seismicity (lack of knowledge!)*

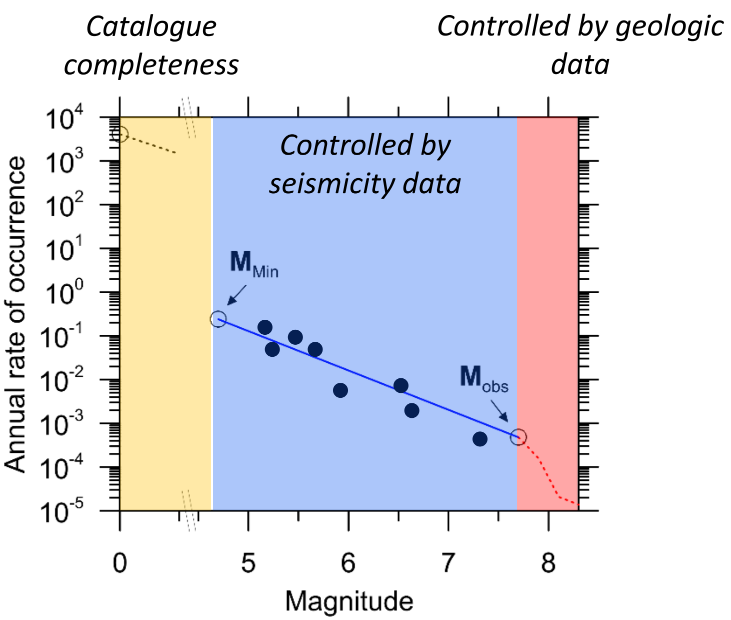


Probabilistic Seismic Hazard Analysis (PSHA)

2. Earthquake recurrence relationship

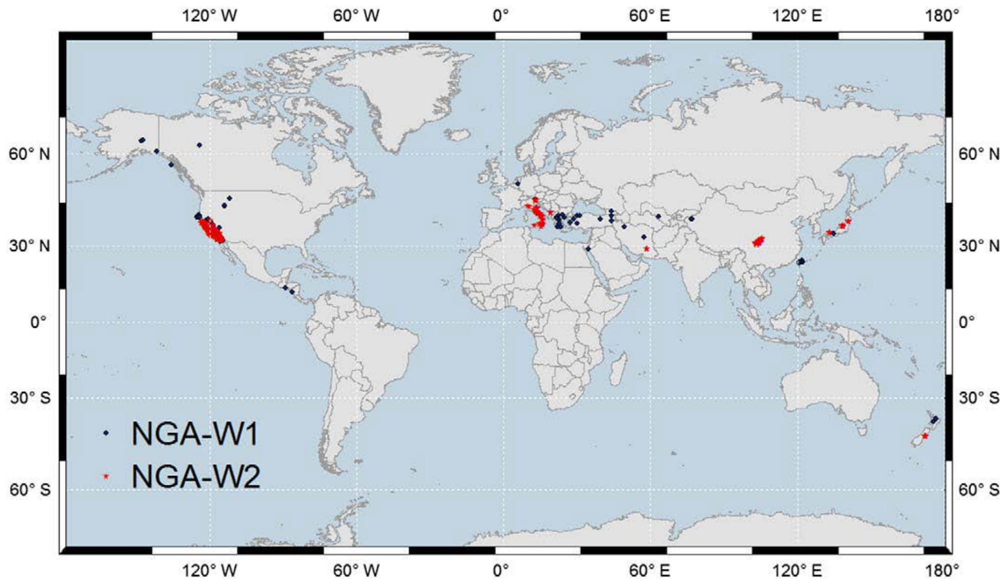
Recorded events

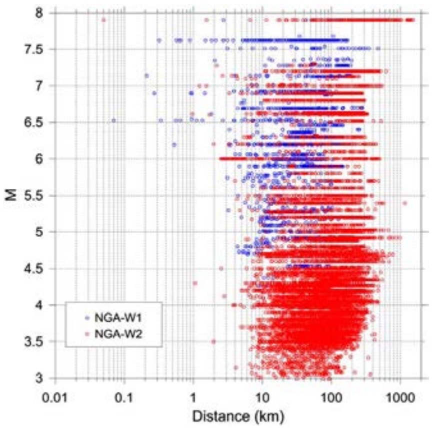




Probabilistic Seismic Hazard Analysis (PSHA)

3. Ground motion models (GMMs) – Based on data



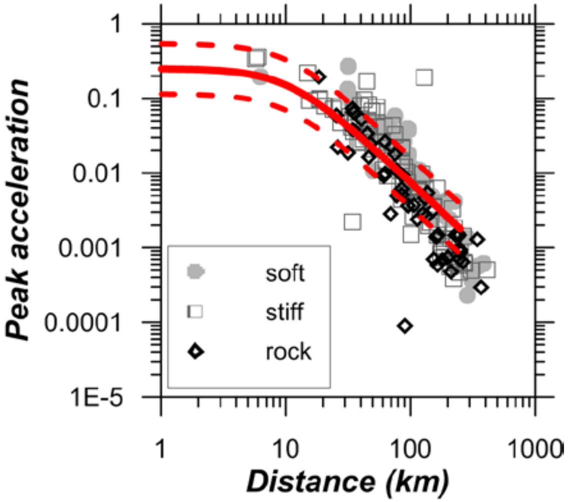


From Ancheta et al. (2014)

NGA project
Global database

GMM functional form

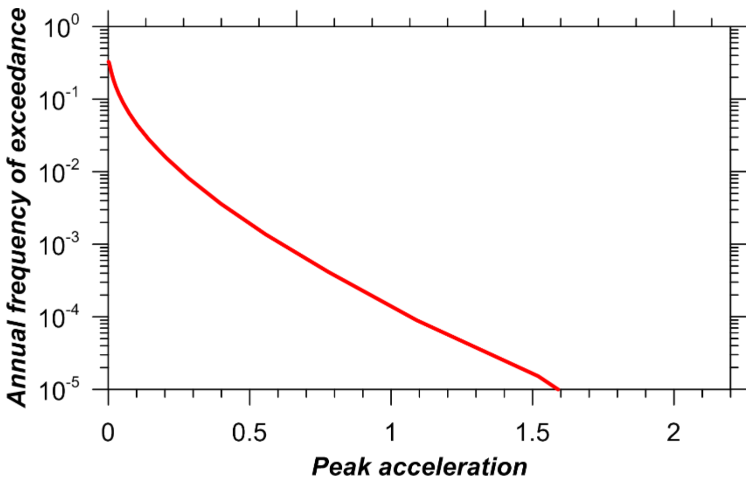
$$\ln(IM) = f(\mathbf{M}, mech) + f(D) + f(V_{S30}) + \sigma$$



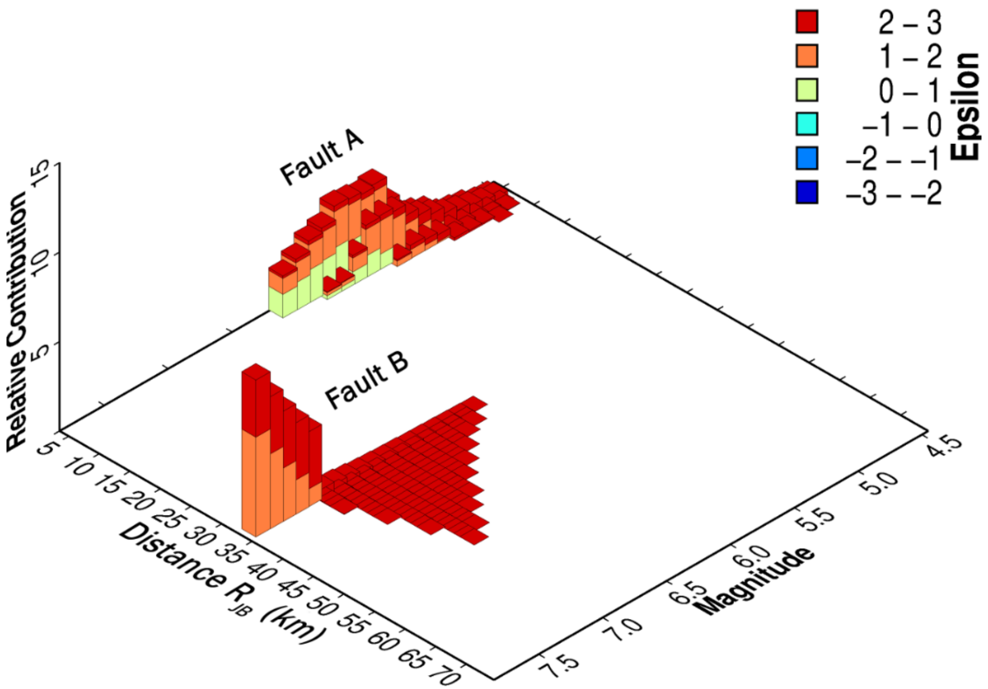
Probabilistic Seismic Hazard Analysis (PSHA)

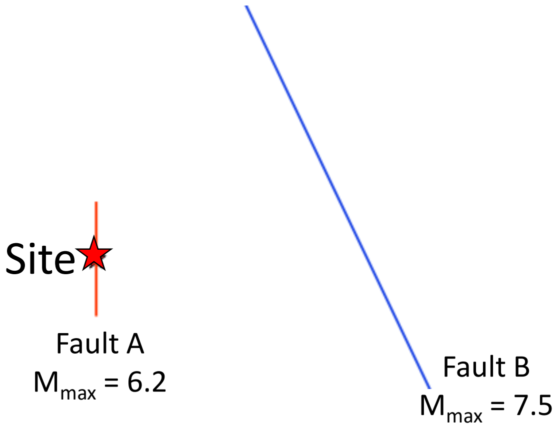
4. Hazard results

Hazard curve



Disaggregation of the seismic hazard

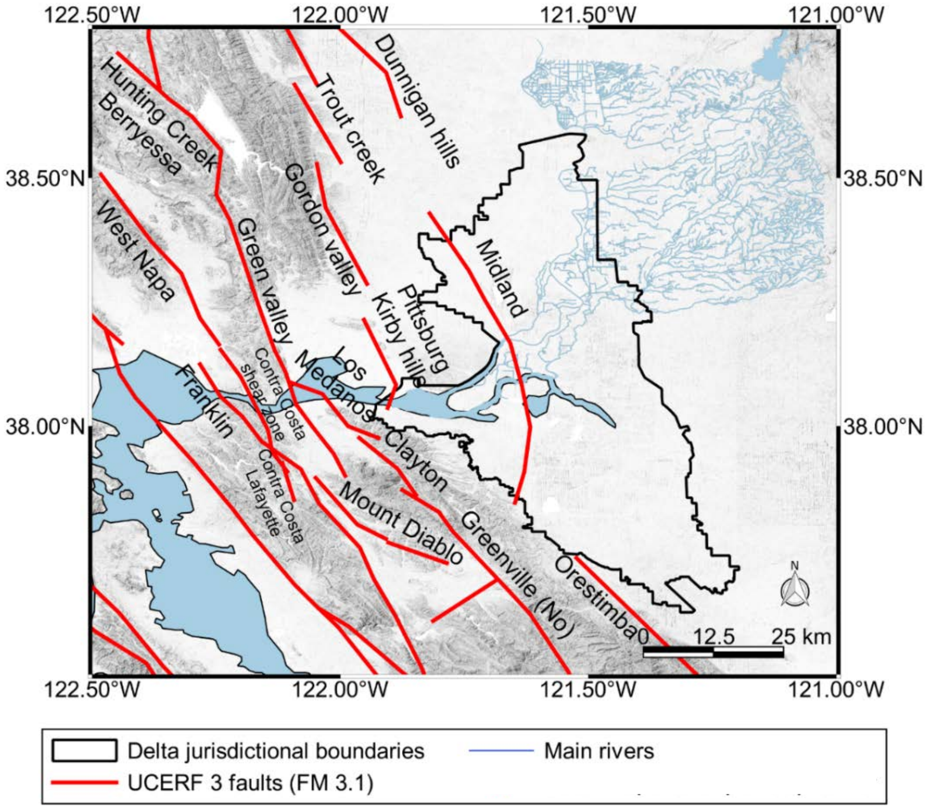


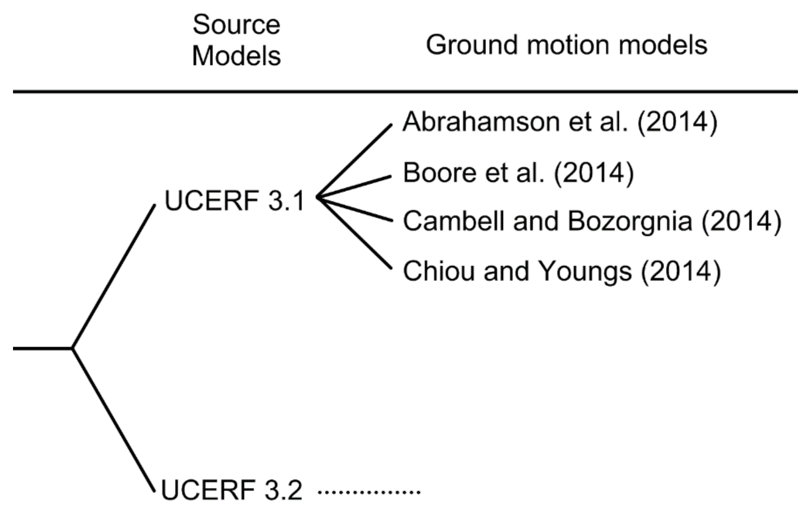


PSHA for the Sacramento-San Joaquin River – This study

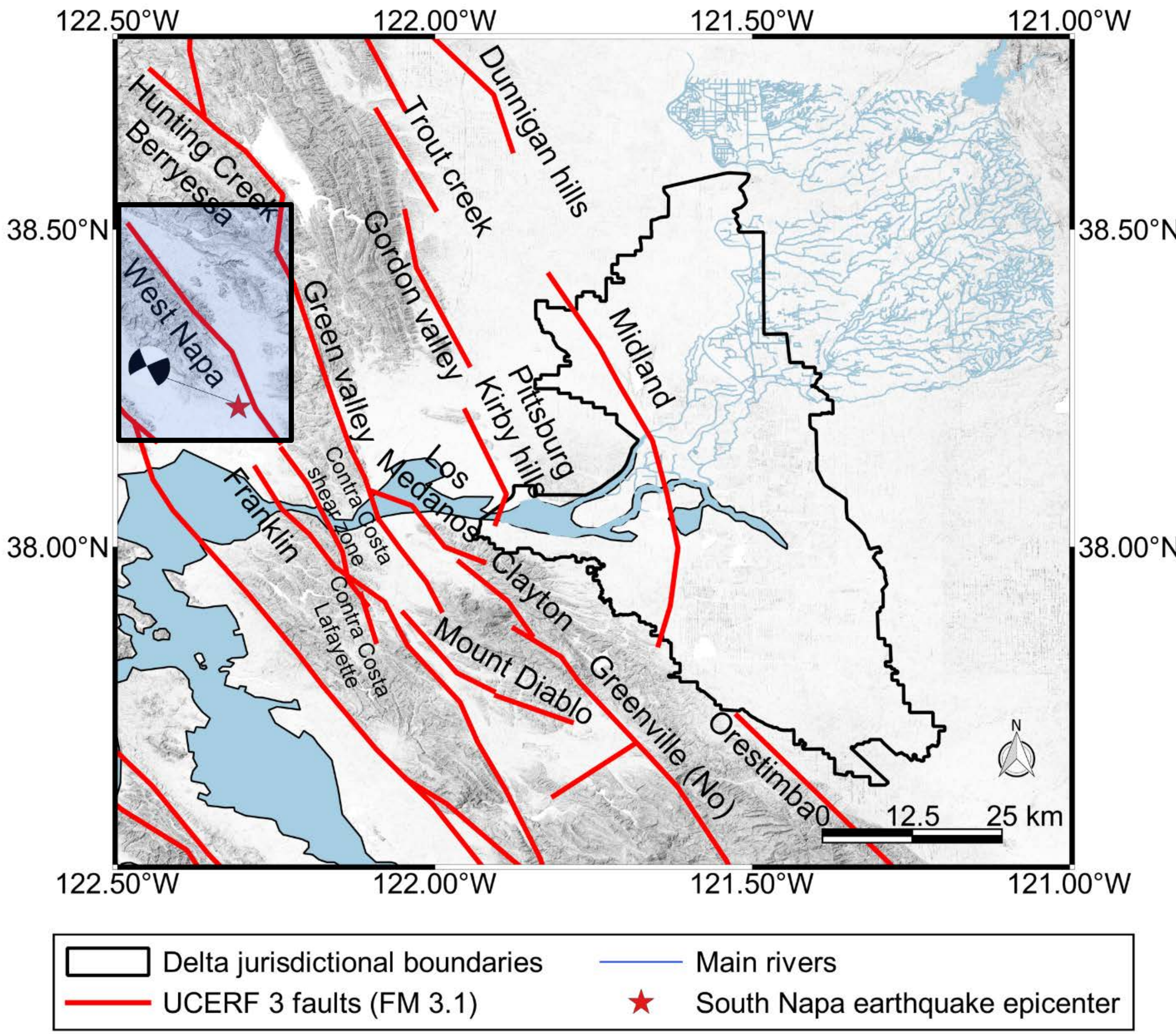
Source model
UCERF3, Field et al. (2014)

Ground motion models
NGA West 2, Bozorgnia et al. (2014)





Seismically-active faults in the Delta – This study



South Napa event 2014 **M**6.0

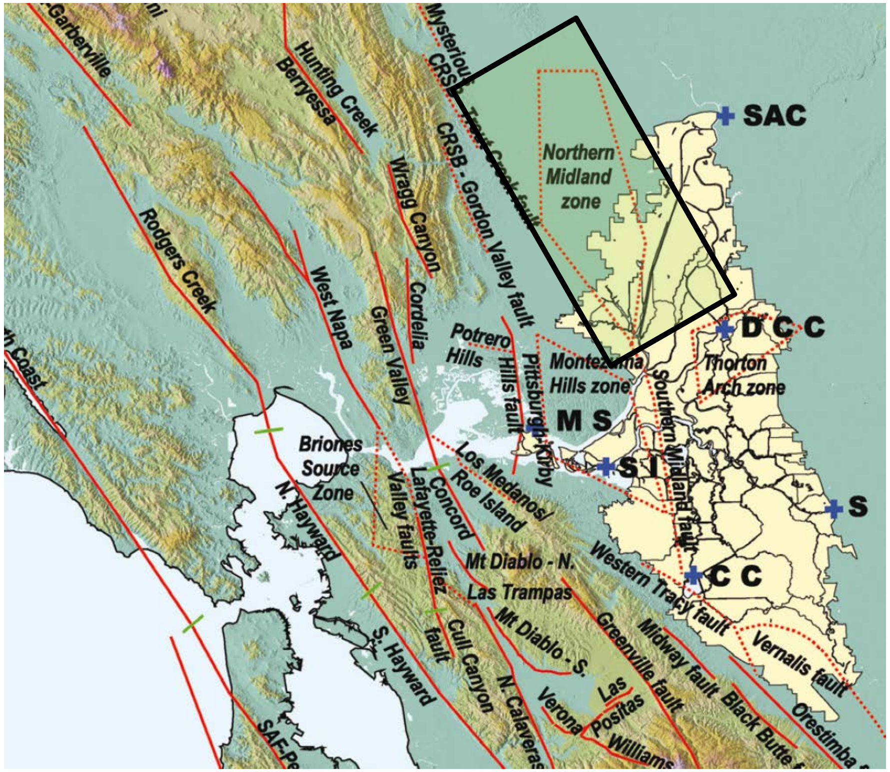
Reminder of the seismicity of the area

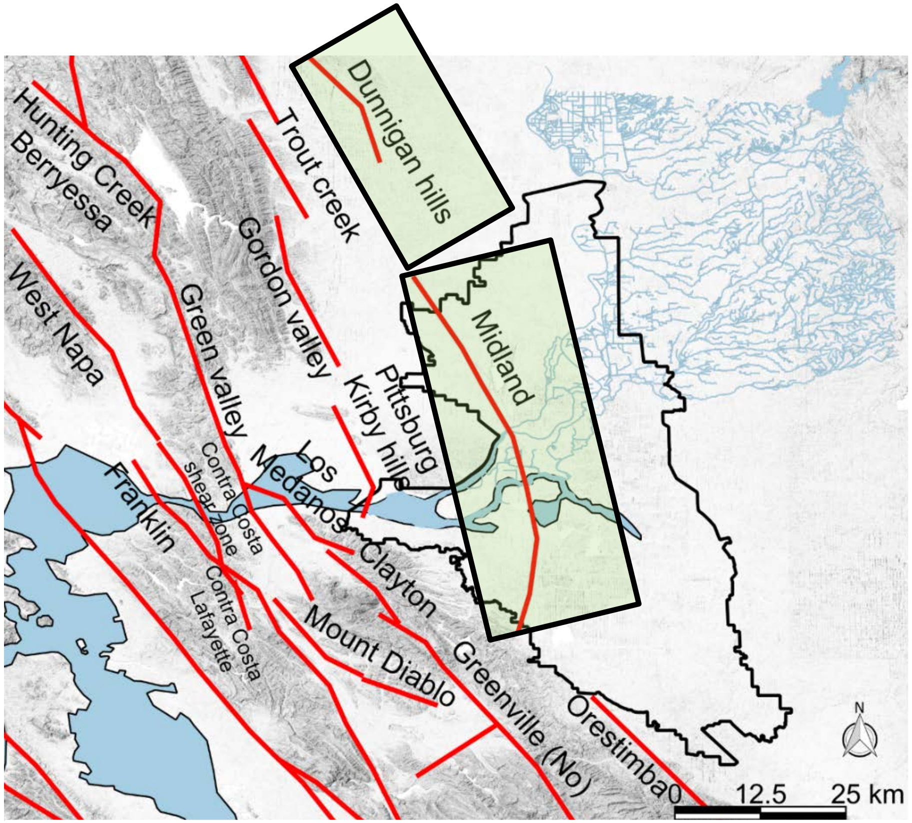
Event occurred on the West Napa fault (Brocher et al., 2015)

Too distant to the Delta produce damage.

Baltay and Boatwright (2015), and Erdem et al. (2016) show that the Delta area has a strong attenuation with distance

DRMS (2009) vs This study

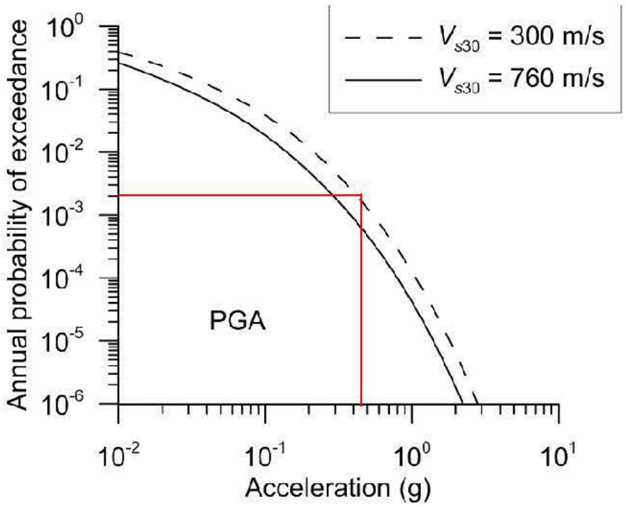




Dunningan Hills fault
background off-fault seismicity
Midland fault

Hazard results for Sherman Island

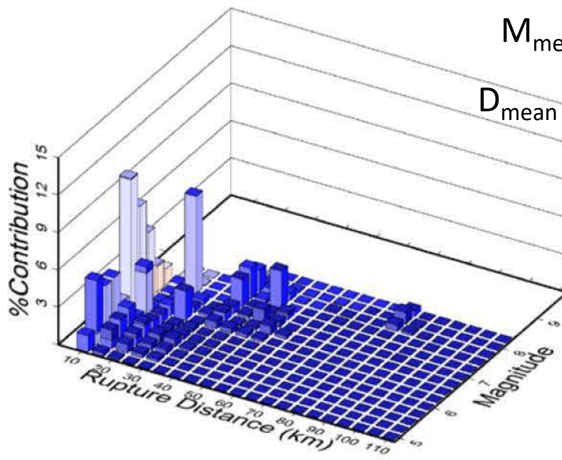
Hazard curve for Peak ground acceleration (PGA)

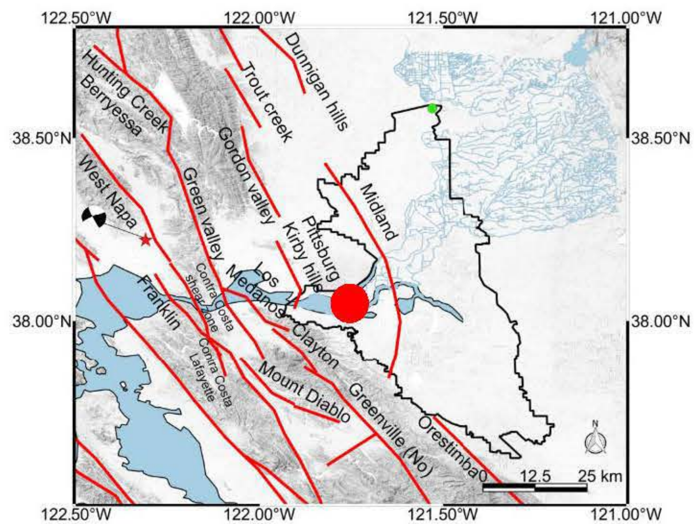


Disaggregation of the seismic hazard:
Sherman Island –T_R = 475 years

M_{mean} = 6.46

D_{mean} = 21.5 km





Disaggregation of the seismic hazard: Sherman Island – T_R = 475 years

	Relative contribution to the hazard (%)
Faults	PGA - V_{S30} = 300 m/s
Pittsburg (Kirby hills)	20.9
Midland	9.28
Green Valley	10.9
Clayton	-
Hayward system	2.46
Rodgers Creek	2.1
Franklin	2.93
Concord	2.33
Calaveras system	2.42
Background seismicity (gridded)	35.1

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Background seismicity has a high relative contribution to the hazard

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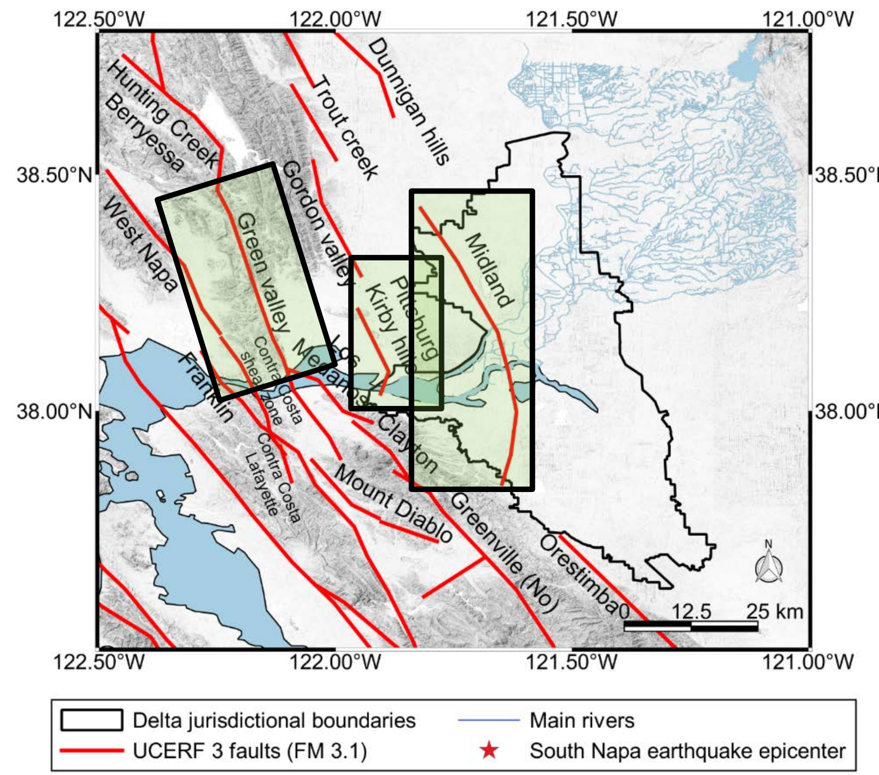
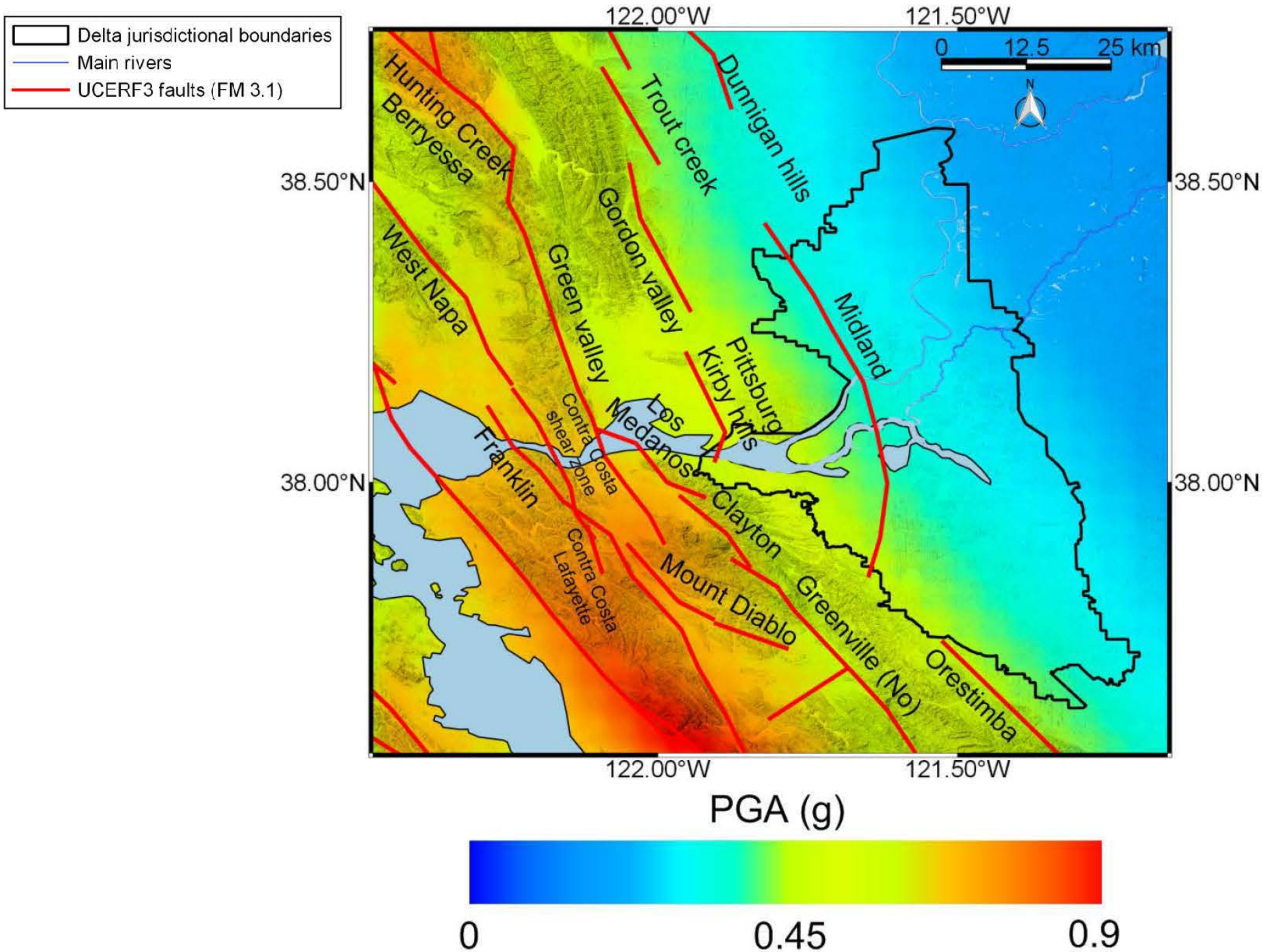
faults characterized by the highest contribution to the hazard are: (1) Pittsburg (Kirby Hills), (2) Green Valley, and (3) Midland.



Hazard Map TR = 475 yrs V_{S30} 300m/s PGA (consistent with soils underlying soft shallow layers)



Conclusions

- *Seismic hazard should be carefully taken into account in the Delta area*
- *The new fault model used in this study (UCERF3) provides better constraints on faults not included in previous inventories*
- *The use of recent GMMs increases the reliability of hazard results*
- *Close faults (e.g. Pittsburg (Kirby Hills), Midland) dominate the hazard in the Delta area*
- *Background seismicity plays an important role for the hazard of the Delta area*
- *Source characterization and site-specific studies will be beneficial*

Thank you!

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