



Impacts of Geo-Spatial Data Resolution on the Uncertainty of Liquefaction-Induced Displacement Estimates

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with

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Liquefaction-Induced Failures of Buried Pipelines



Balboa Blvd Pipes

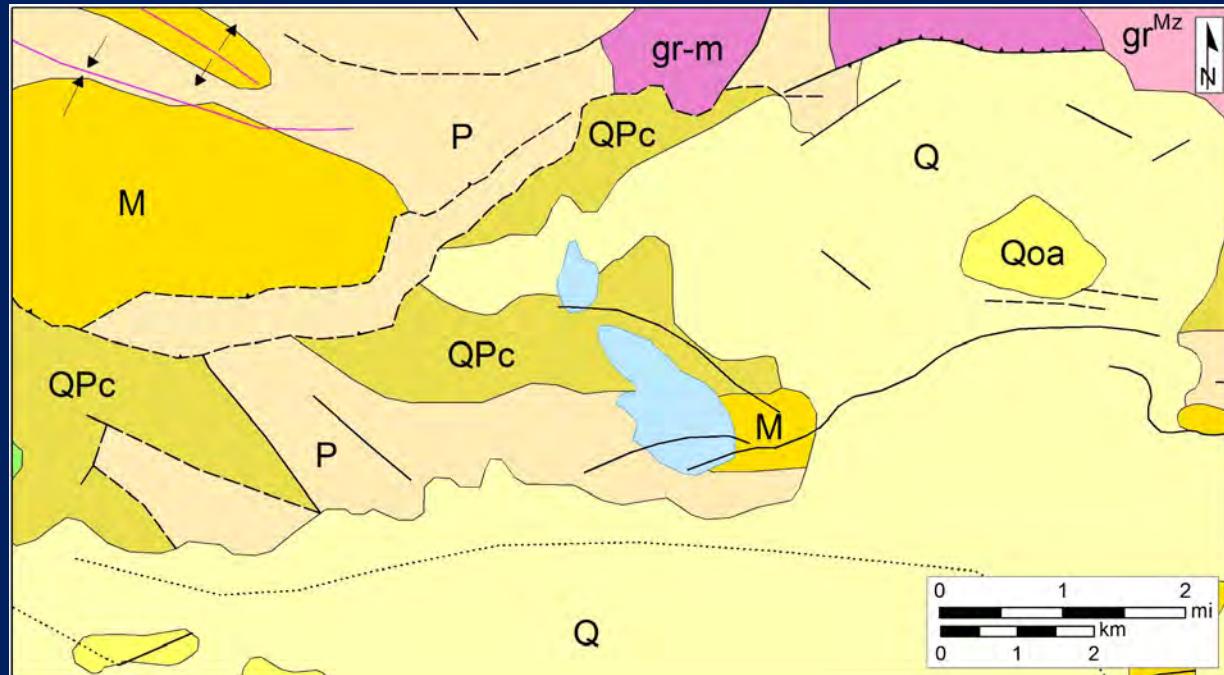
1994 Northridge EQ



Granada Trunk Line
O'Rourke & Palmer 1994

Geologic Data Levels at Different Scales

Level 1 Geologic Map



CGS Digital CA Geologic Map 1:750,000
(Jennings 1977; updated by Gutierrez et al. 2010)

Level 2 Geologic Map



Bedrossian (2012) Geologic Map 1:100,000

Lateral Spreading Data Levels

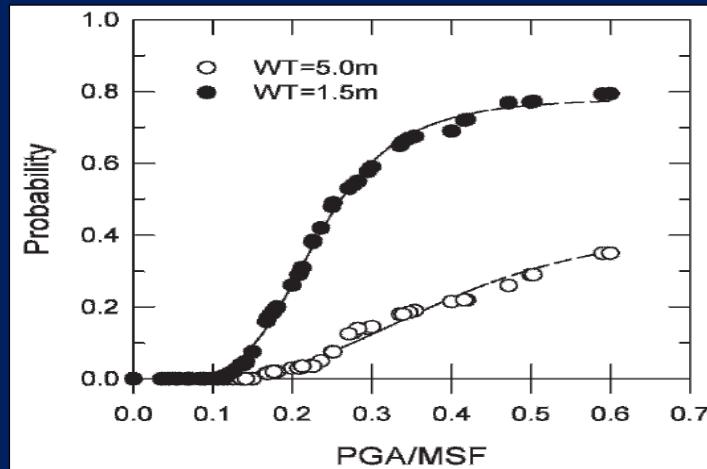
| | Level 1 – State-Wide | Level 2 - Region | Level 3 – Site Specific | Level 4 - Advanced |
|--|--|---|---|---|
| Lateral Spreading Model Inputs & Outputs | <p>A) Zhu et al. (2017) models combined with HAZUS to estimate lateral spread displacement (D) <u>Inputs:</u> PGV, inferred V_{S30}, precip, d_c, d_r, d_w, modeled GWT <u>Outputs:</u> Liquefaction Susceptibility Class converted to D</p> | <p>A) Youd & Perkins (1978) and Witter et al. (2006) geologic based assessments used with HAZUS to estimate D <u>Inputs:</u> Surficial Quaternary geologic maps, PGA, M_w, GWT <u>Outputs:</u> Liquefaction susceptibility converted to D</p> | <p>A) Zhang et al. (2004) <u>Inputs:</u> CPT, PGA, M_w, GWT, topography <u>Outputs:</u> Estimate of D</p> <p>B) Youd et al. (2002) <u>Inputs:</u> Boring with $(N_1)_{60}$, W, S, T_{15}, F_{15}, $D50_{15}$ <u>Outputs:</u> Estimate of D</p> <p>C) Faris et al. (2006) <u>Inputs:</u> CPT, PGA, M_w, GWT, topography <u>Outputs:</u> Estimate of D</p> | <p>Level 3 methods and advanced analyses (e.g., using FLAC, PLAXIS, OpenSees)</p> |

Lateral Spreading Data Levels

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New Regional Lateral Spread Procedure

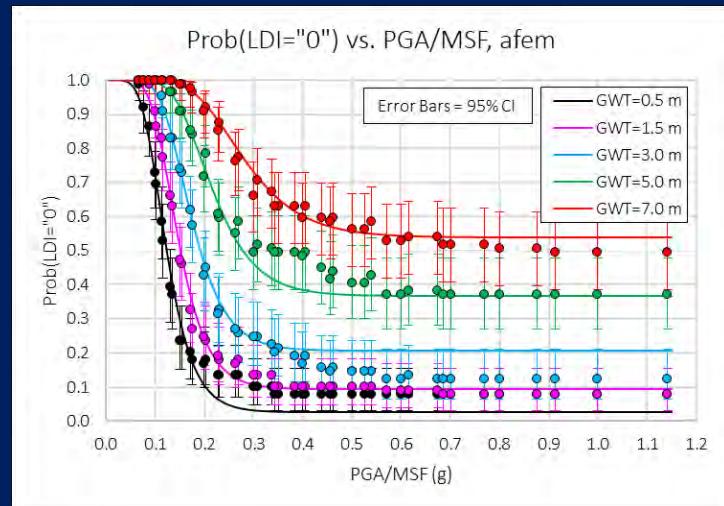
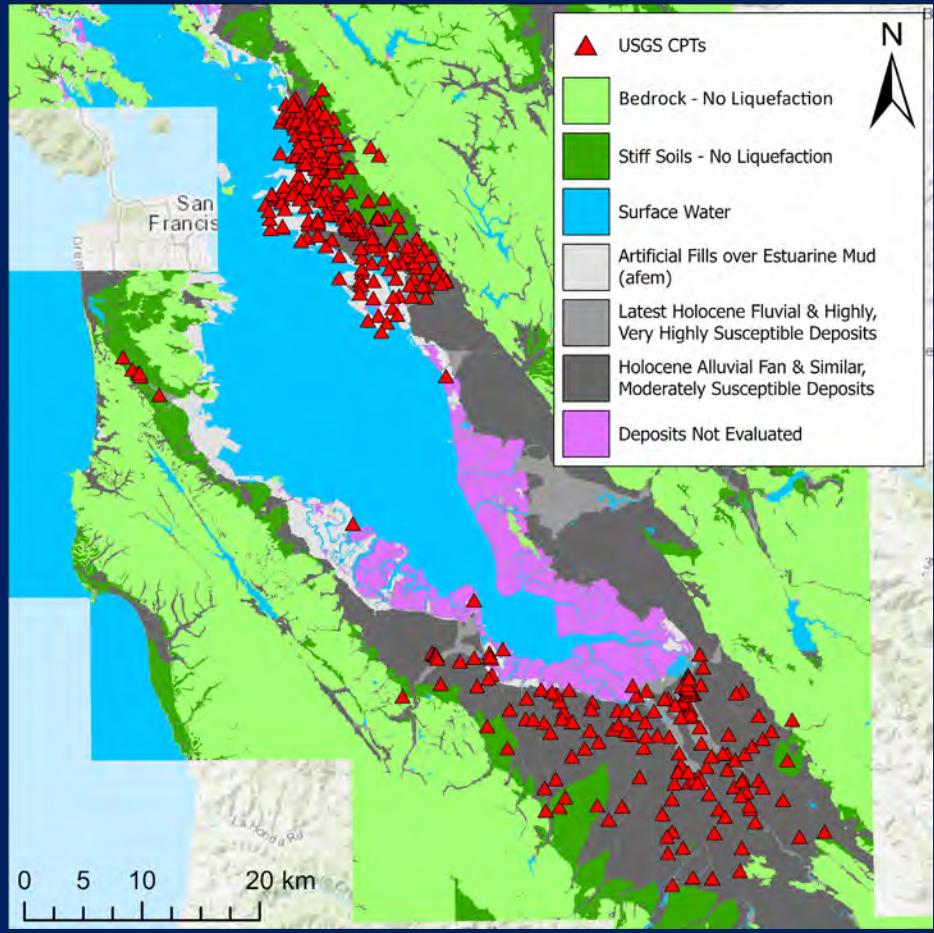
- Extend Holzer et al. (2011) “Liquefaction Probability Curves for Surficial Geologic Units” methodology



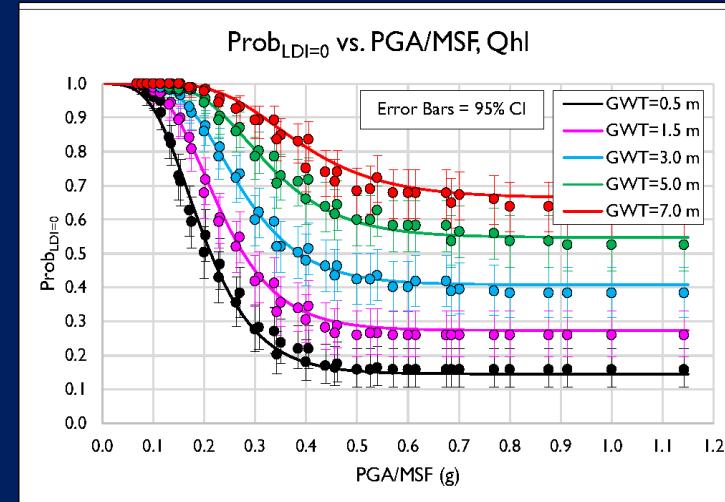
CPT-Based Liquefaction Probability Curves for Artificial Fill Deposits in Bay Area

- Collect CPTs in study area for each surficial geologic unit
- Calculate Lateral Displacement Index (LDI) for 225 combinations of PGA, M_w , GWT
- Derive equations for Probability of LDI=“0” and Distribution of non-zero LDI
- Convert LDI to Lateral Spread Displacement (D) using existing topographic relationships
- Use maps of PGA, surficial geology, GWT, and topography to estimate D at regional scale

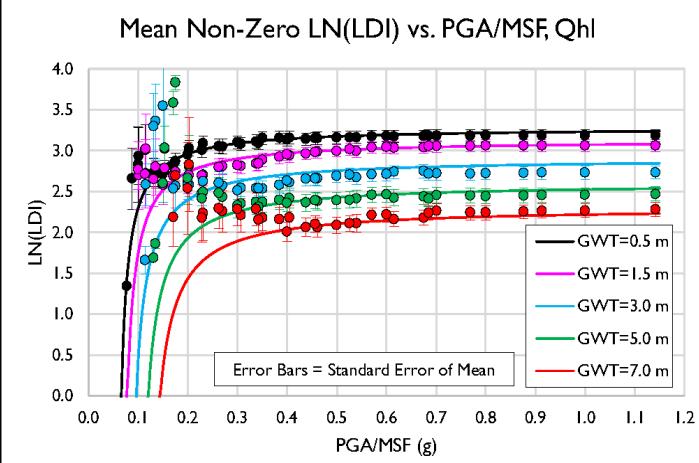
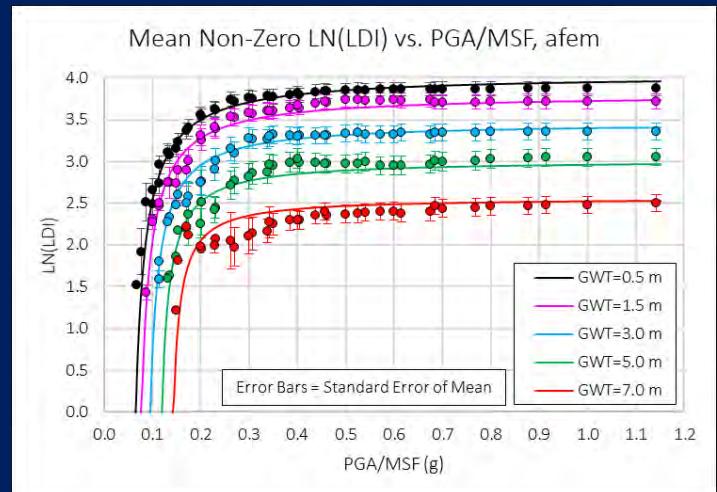
1989 Loma Prieta EQ in SF Bay



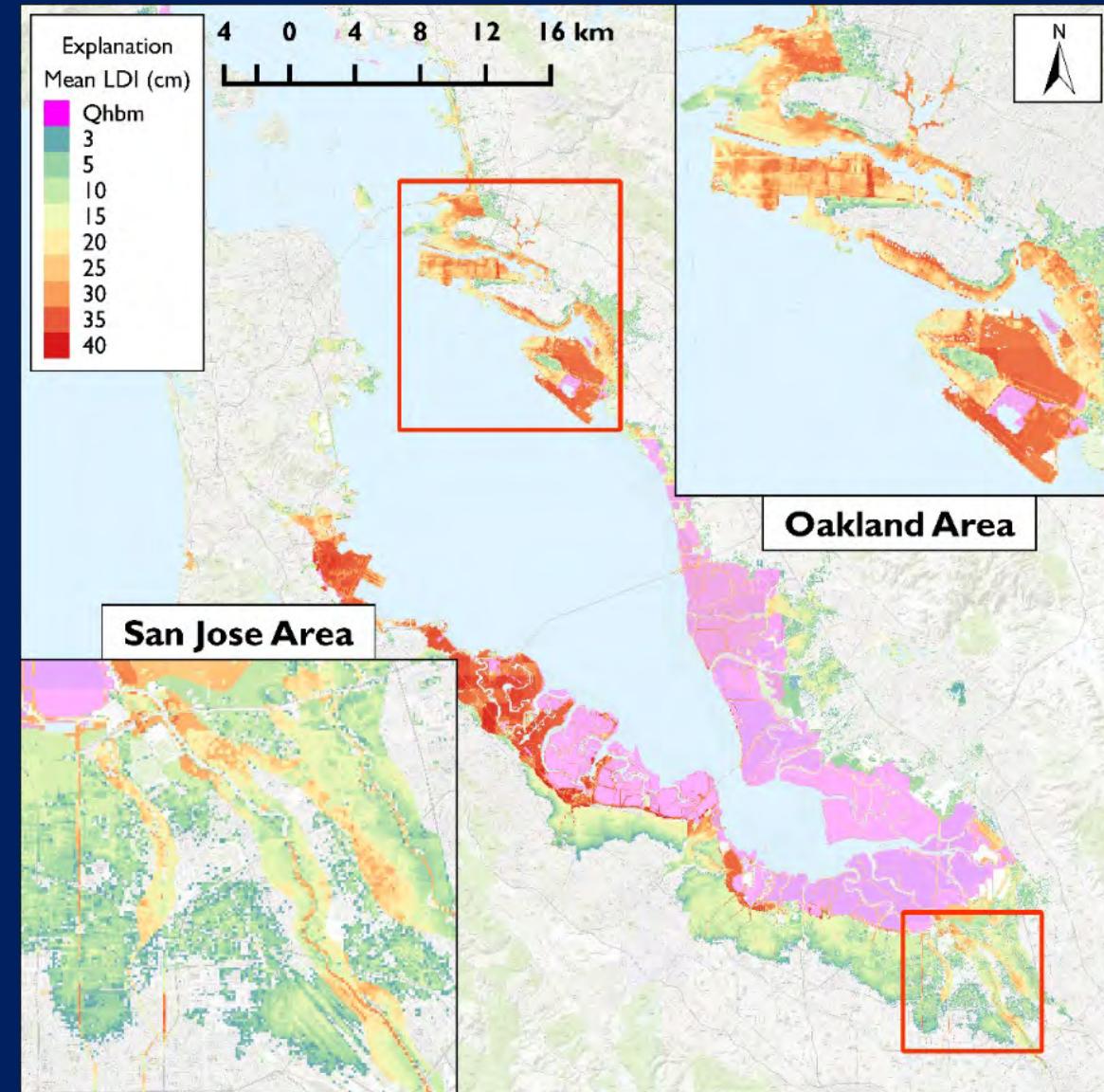
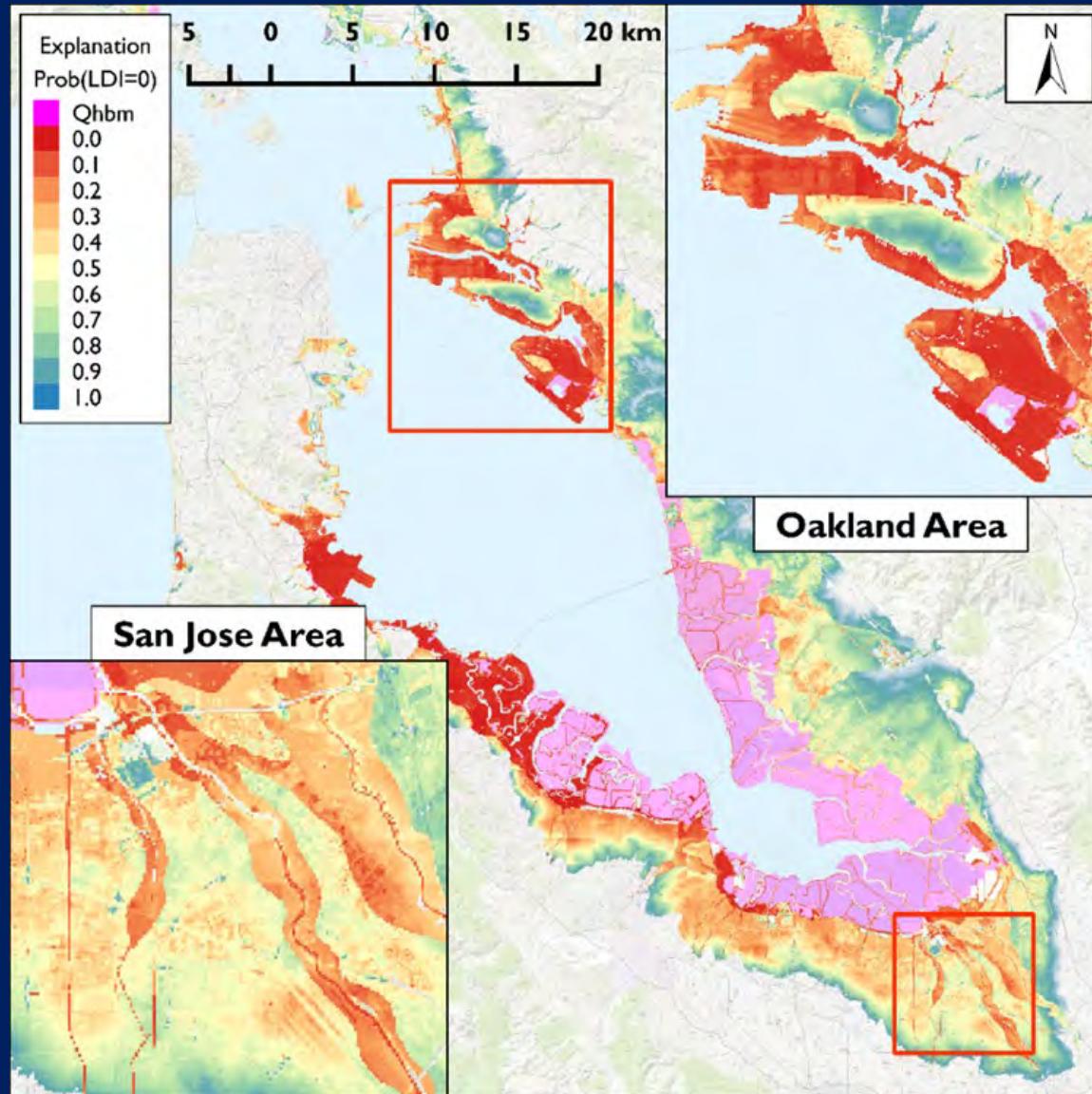
Artificial Fill over Bay Mud



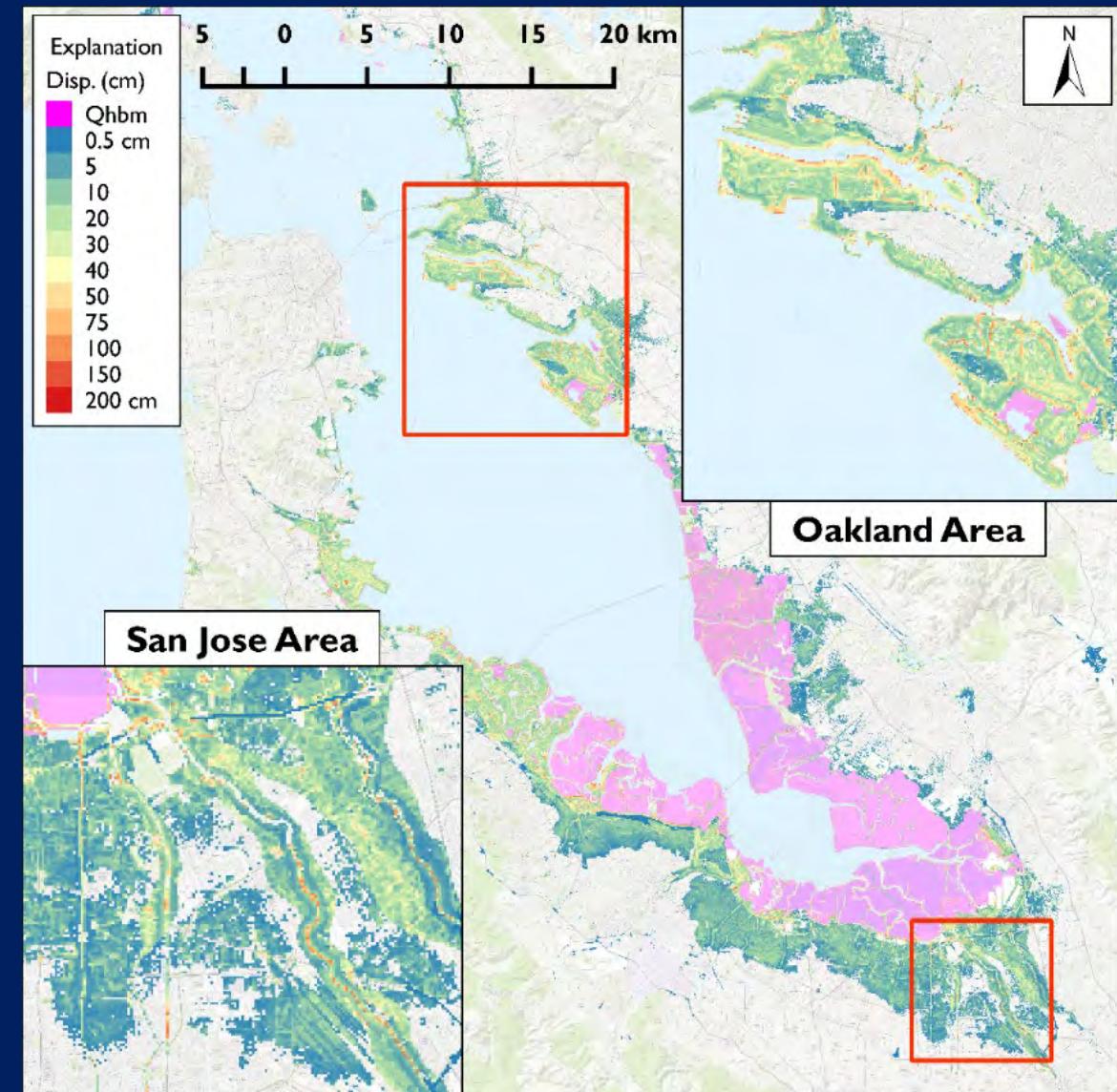
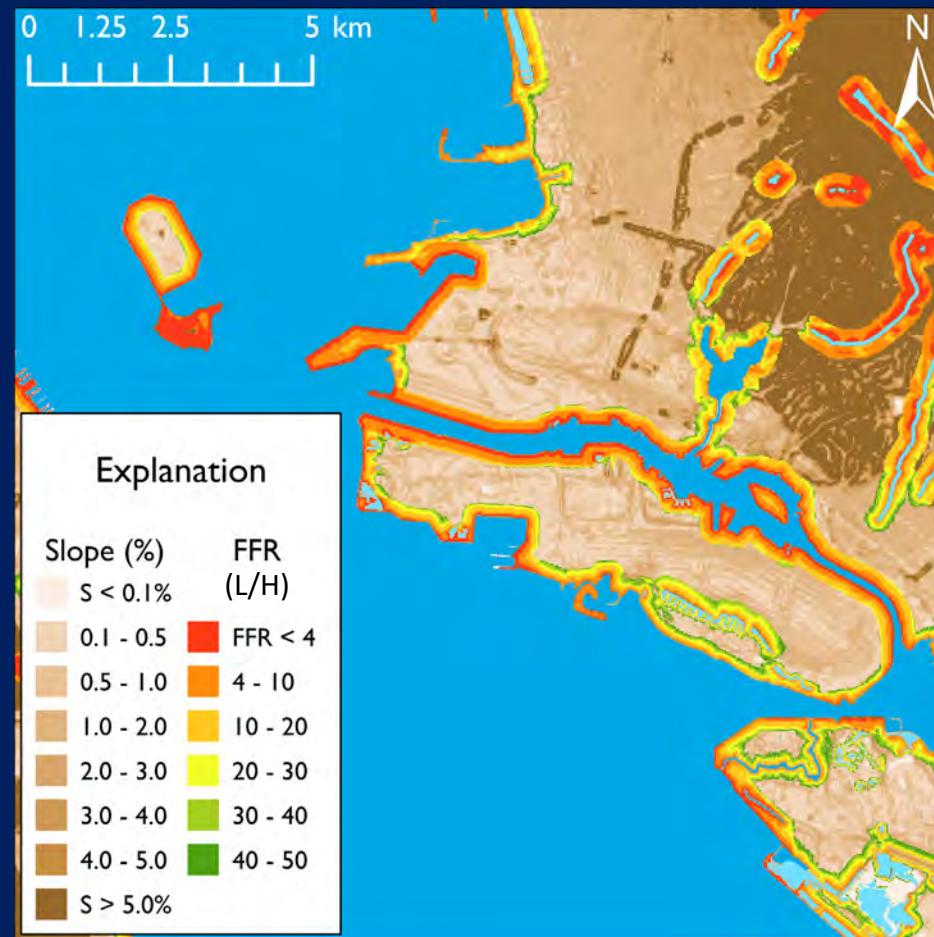
Holocene Alluvial Fan Deposits



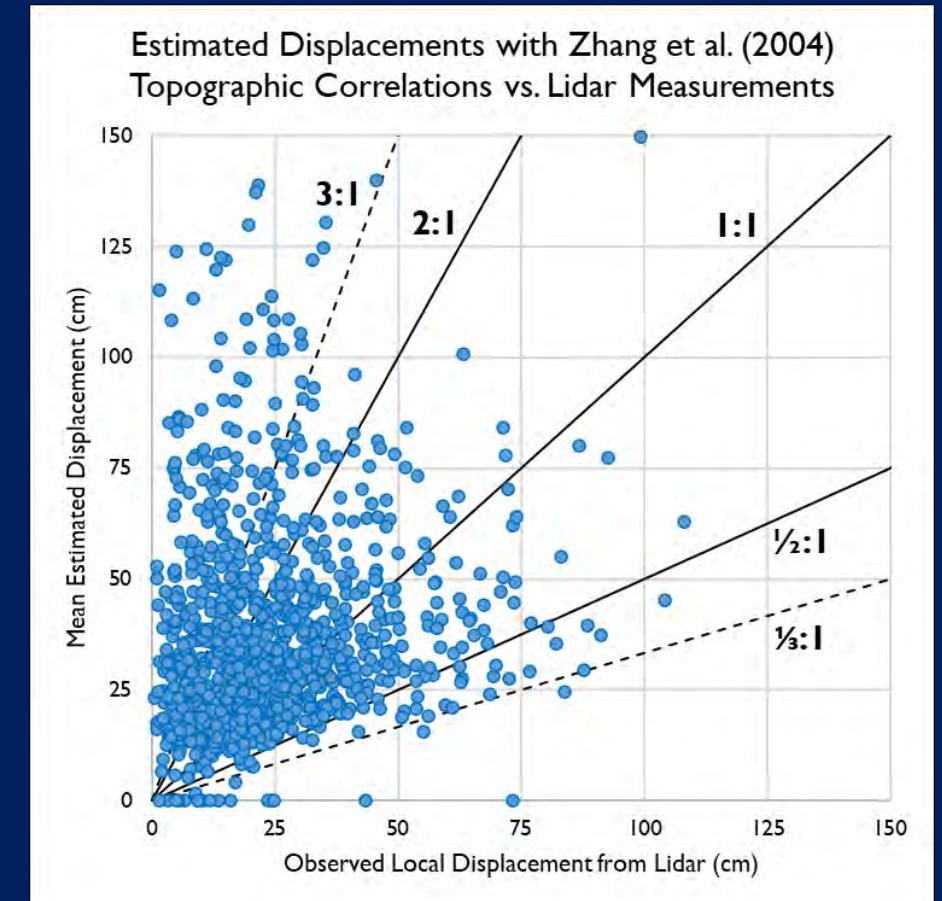
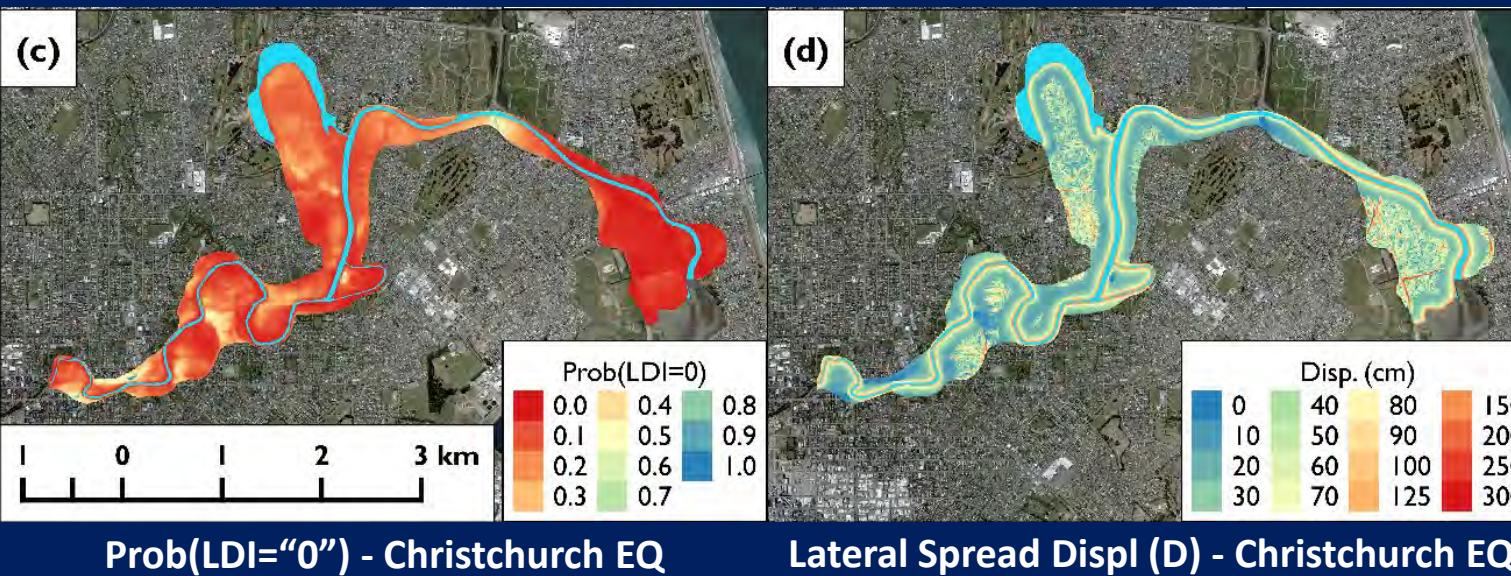
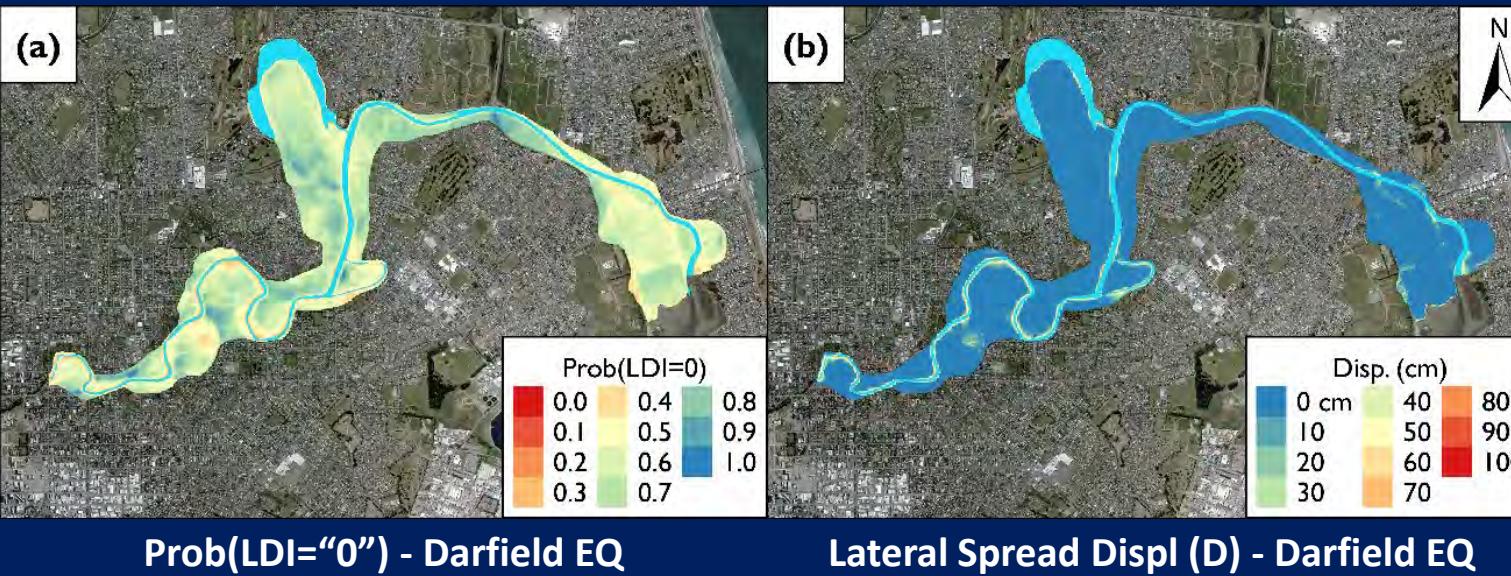
1989 Loma Prieta EQ in SF Bay



1989 Loma Prieta EQ in SF Bay



2010 Darfield & 2011 Christchurch EQs in New Zealand



Estimated Mean Displacements vs.
Measured Displacements - Christchurch EQ

Conclusions

- Employ state-wide, regional, & site-specific data levels in *OpenSRA* to perform geo-hazard analyses
- Regional probabilistic liquefaction-induced lateral spread procedure developed as alternative to existing Level 2 Hazus method
- Back-analyses of Loma Prieta EQ in SF Bay Area and Darfield & Christchurch EQ in Canterbury region show promising results
- Ongoing work focused on reducing overestimation of spatial extent of lateral spreading, especially in areas with slightly sloping ground