

Implications of Seismic Design Values for Economic Losses

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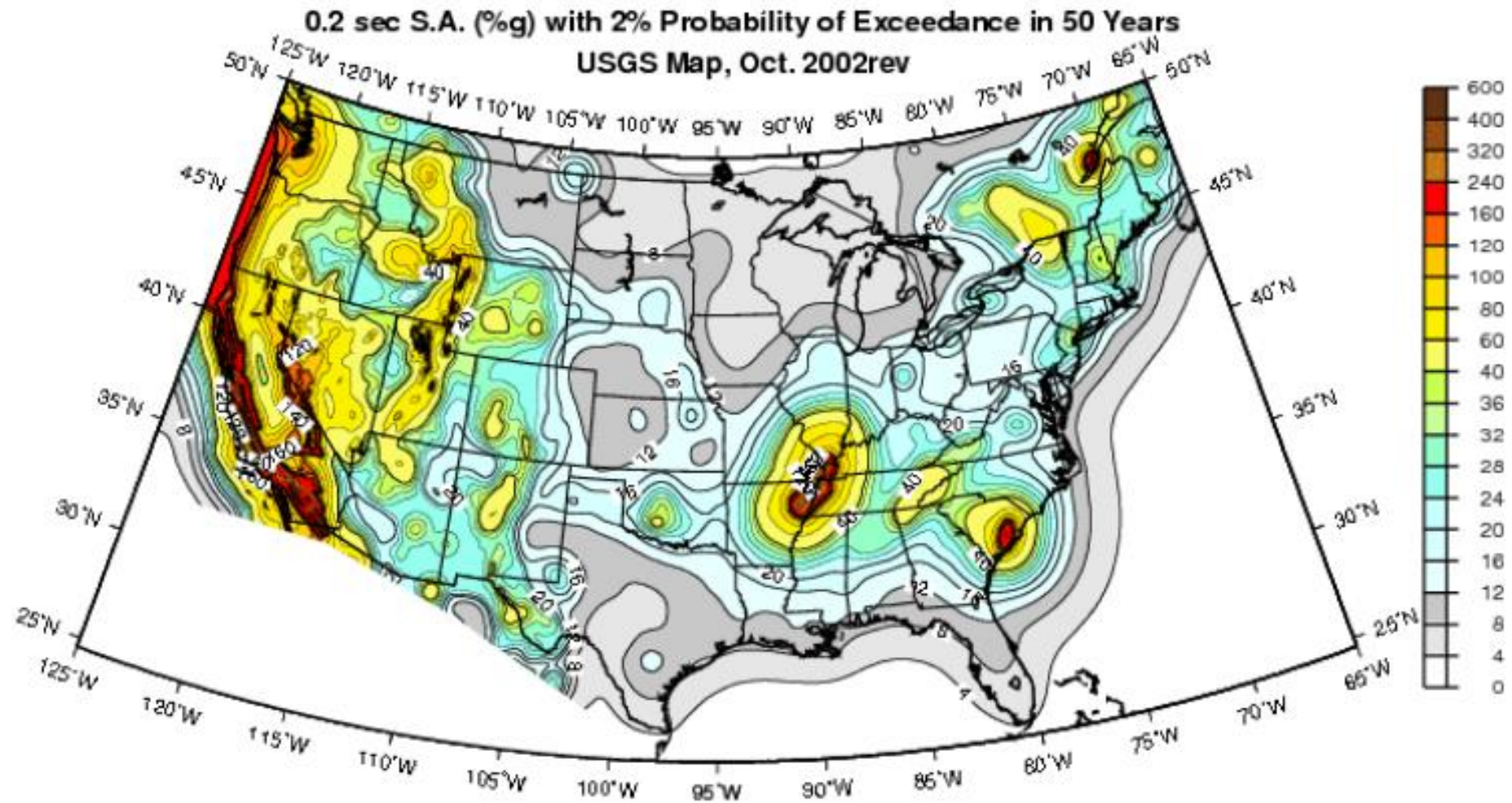
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Our Goal

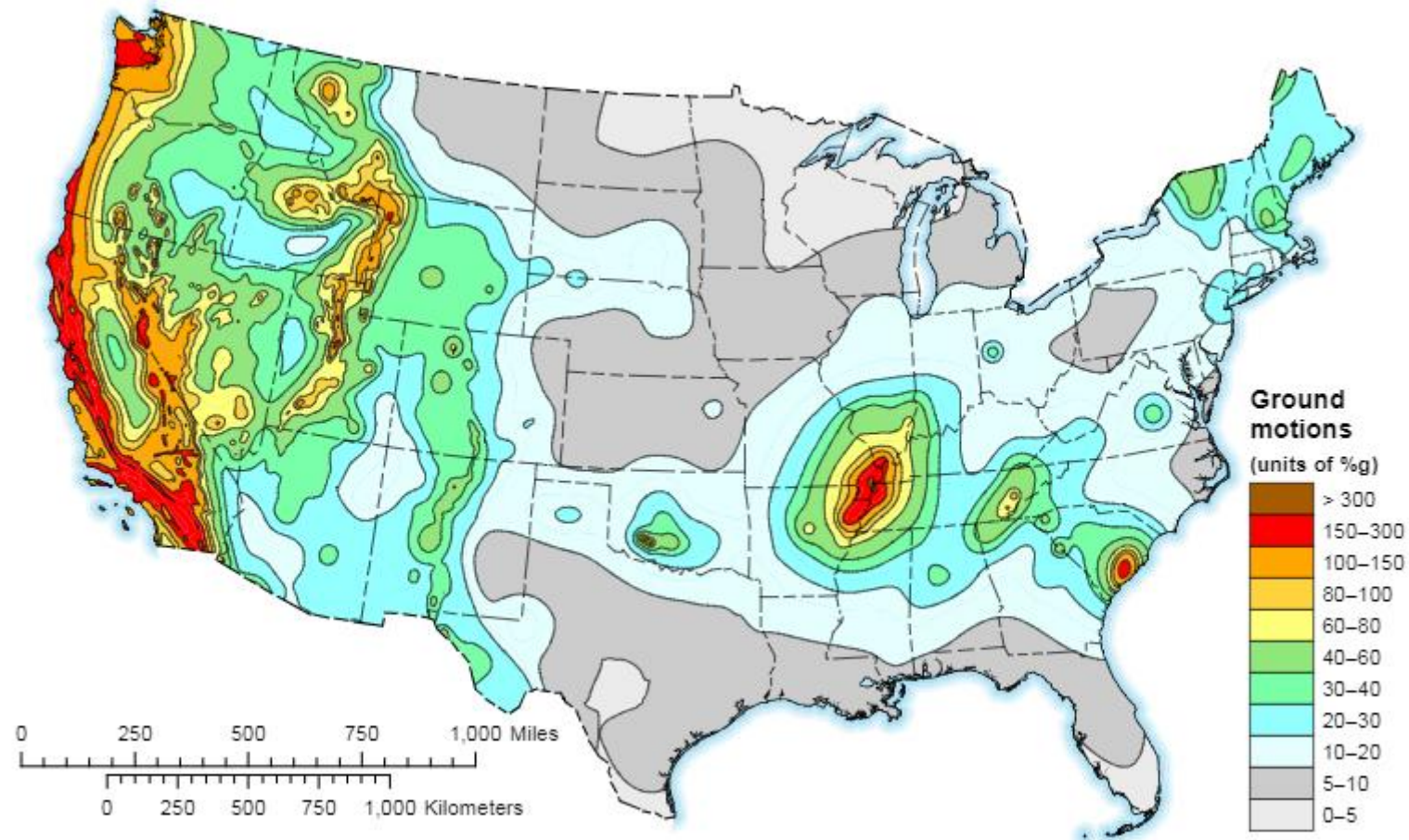
To quantify earthquake-induced economic losses for buildings, considering design values obtained from deterministic and probabilistic hazard maps.

U.S. Seismic Design Maps: Uniform Hazard Values



<https://earthquake.usgs.gov>

U.S. Seismic Design Maps: Risk-Targeted Values

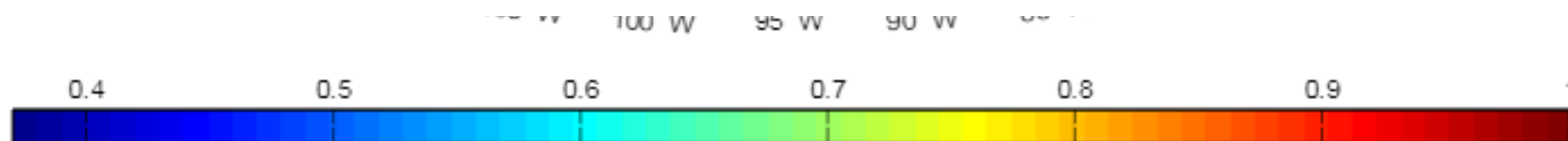


Luco, et al. (2017)

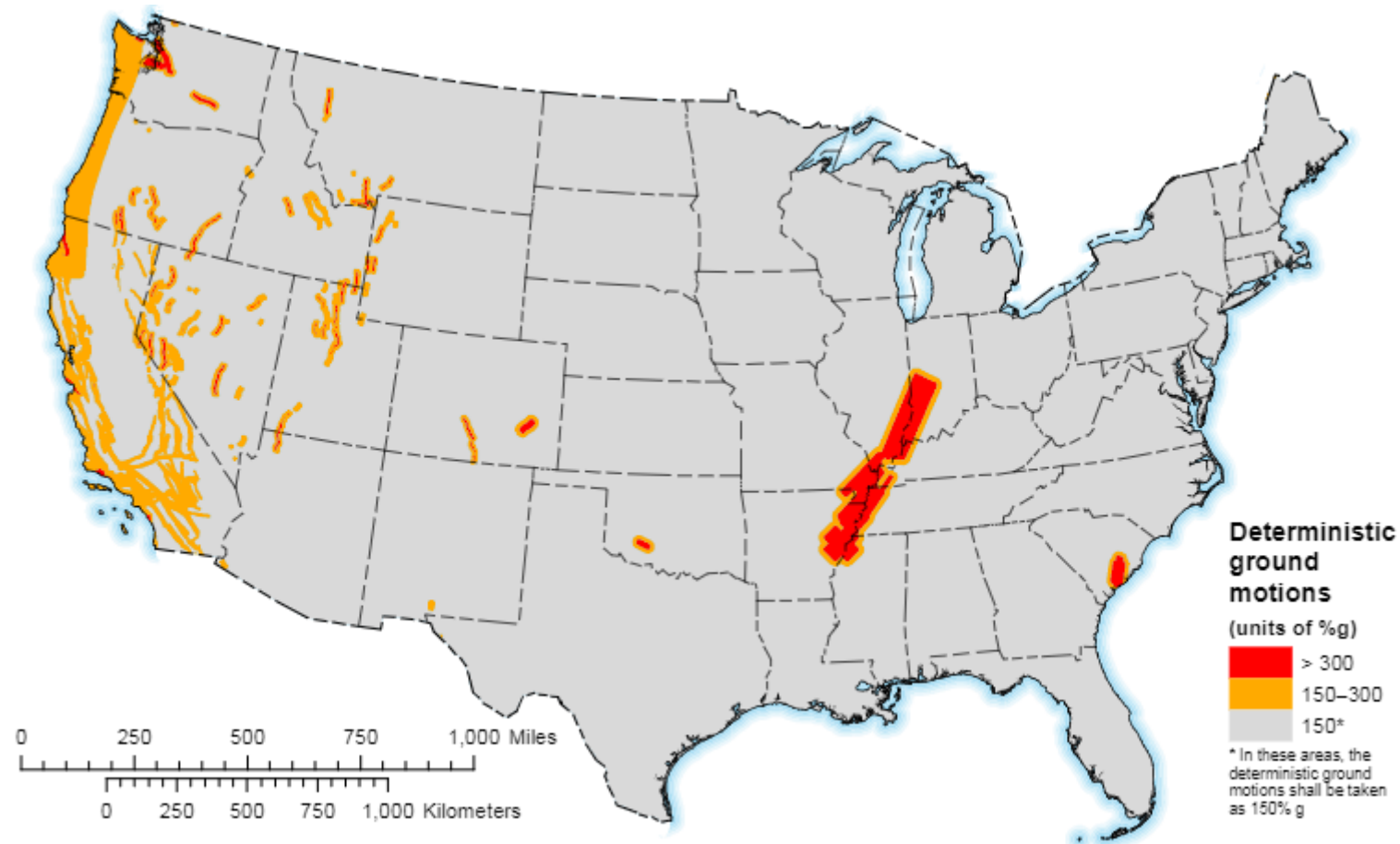
U.S. Seismic Design Maps: Changes between Uniform Hazard and Risk Targeted



Figure 1. Maps of the ratio of the MCE ground motions in the 2003 NEHRP Provisions to the uniform-hazard (2% probability of exceedance in 50 years) ground motions from the USGS (Frankel et al., 2002). This paper focuses on the probabilistic portion of the current seismic design maps, shown in white.

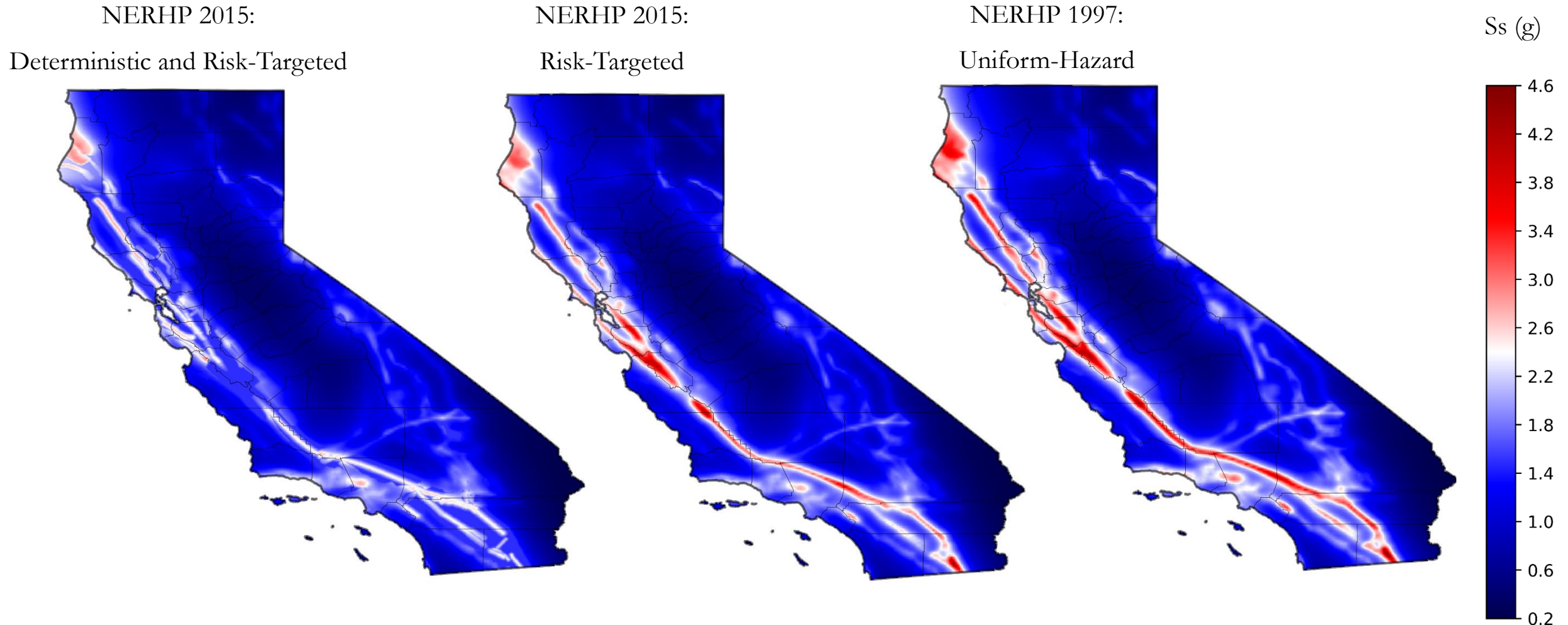


U.S. Seismic Design Maps: Deterministic Values



Luco, N., Liu, T. J., & Rukstales, K. S. (2017).

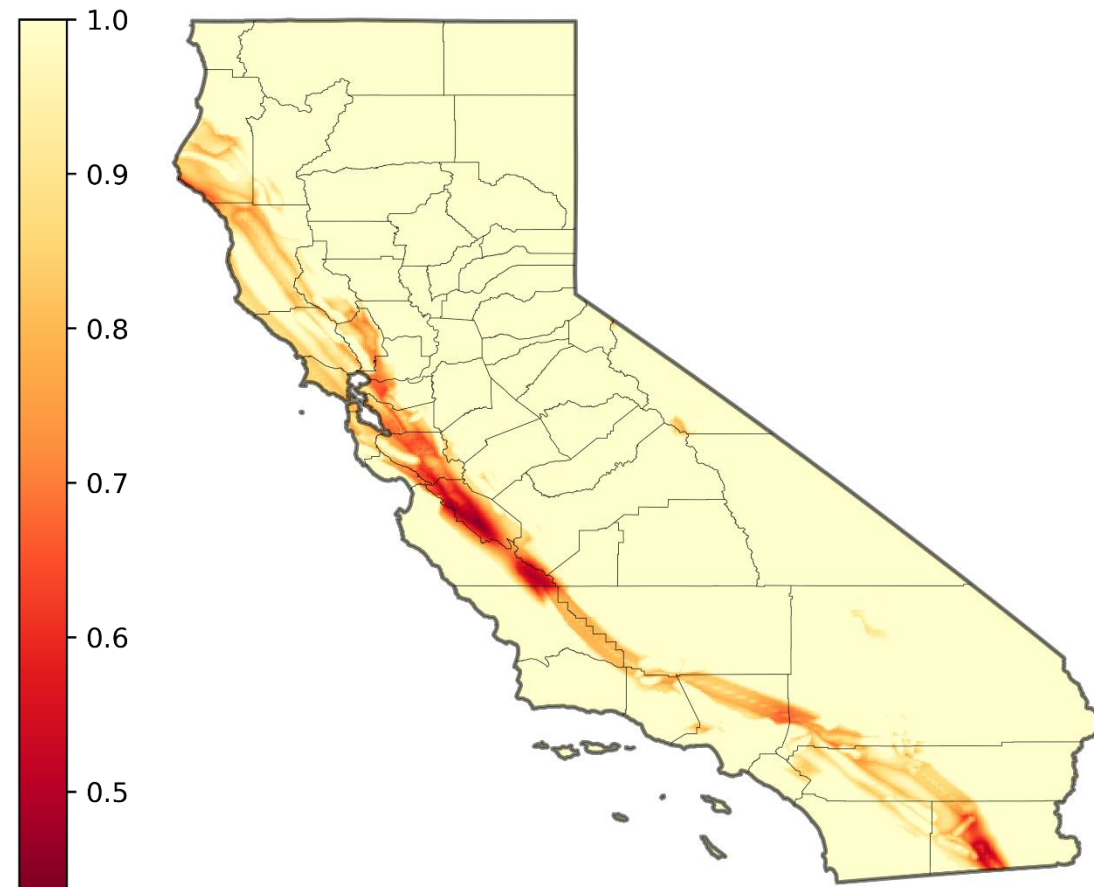
Variations in Short Period Spectral Acceleration Design Values



Variations in Short Period Spectral Acceleration Design Values

NERHP 2009:

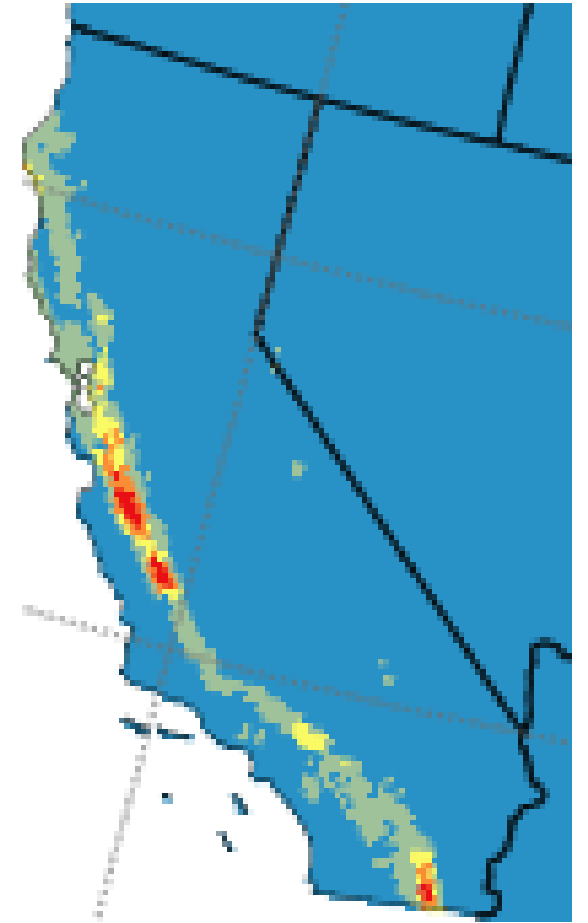
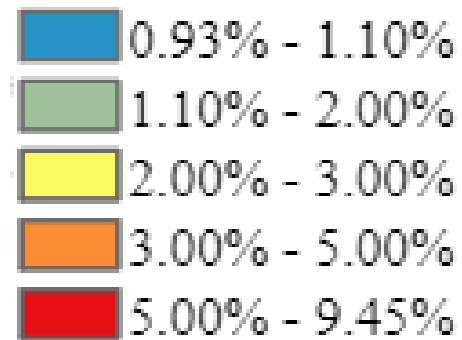
Deterministic / Risk-Targeted



Implications of Risk Targeted v Deterministic Maps

Buildings in near-fault regions are designed for smaller levels of shaking and may incur higher risks, potentially up to a nine times higher risk of collapse

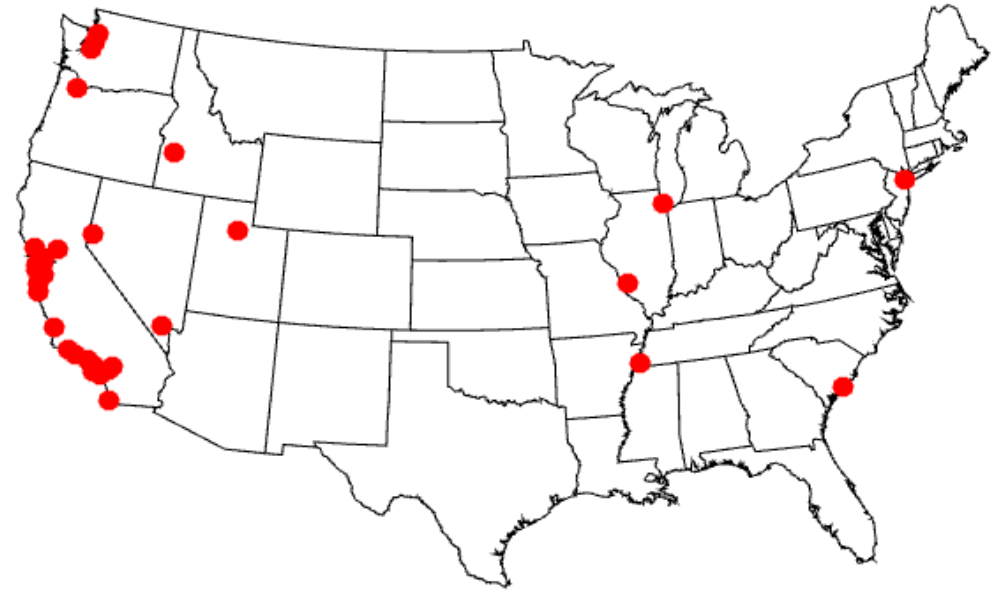
Collapse Risk, probability in 50 years



Luco, et al. (2017)

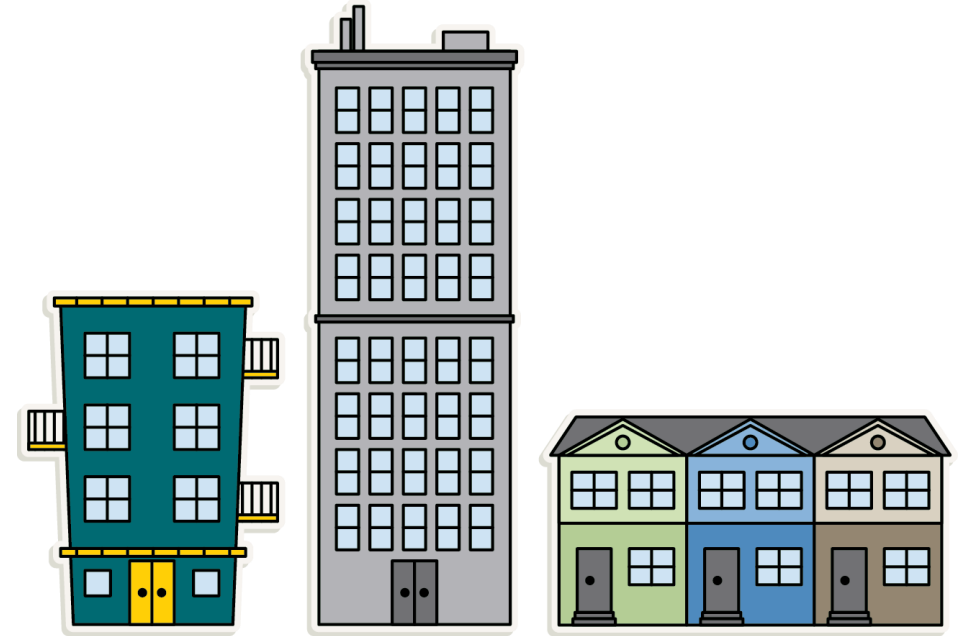
Methodology

- Investigated the differences in seismic loss predictions according to three different seismic design maps
- Developed a set of over 500 models that represent various building types and occupancies common to US construction, across the U.S.
- Quantified seismic losses in terms of building repair cost using the SP3 Risk Model.



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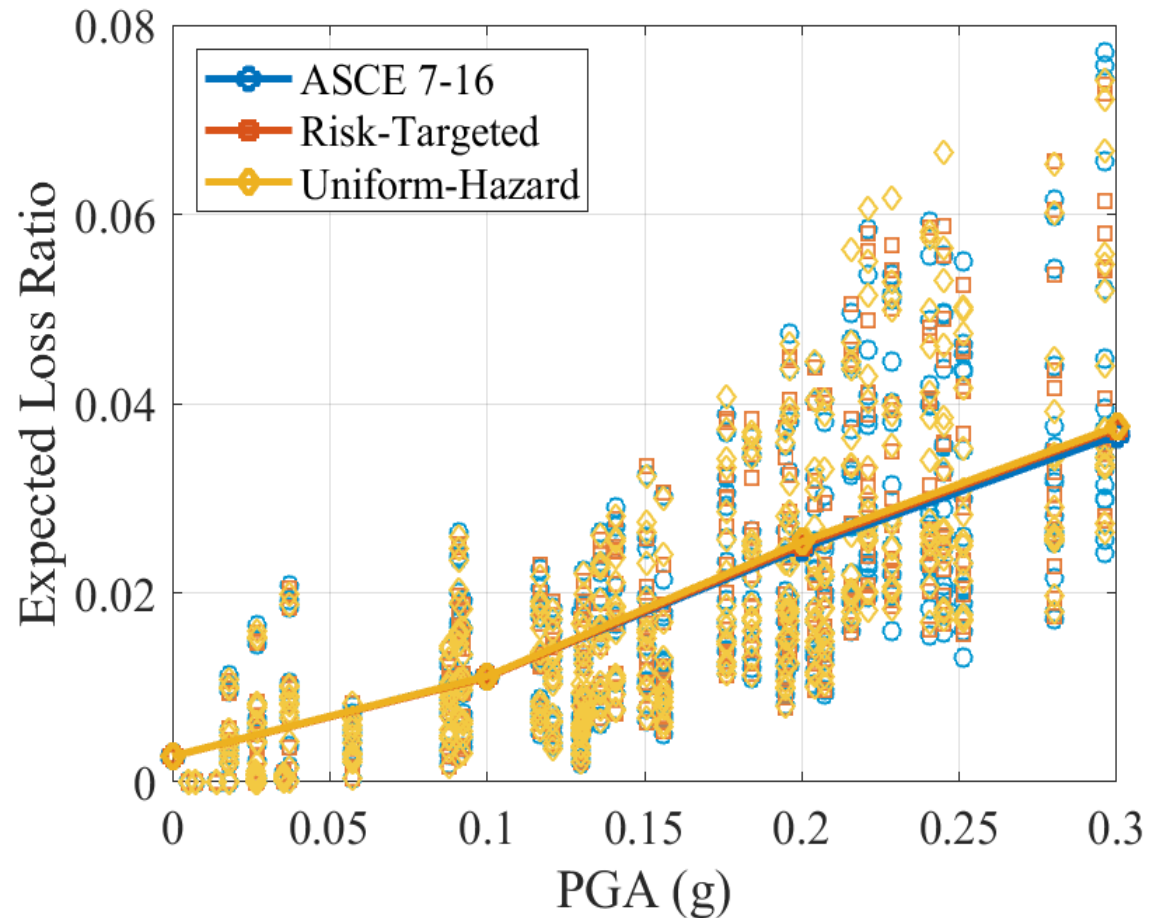
SP3 Risk Model

- Quantifies expected seismic losses according to the FEMA P-58 method.
- Streamlines P-58 process such that a risk assessment can be performed with limited inputs.
- Building types that were assessed as part of this study are based on default building types, structural response characteristics, and component populations of the SP3 Risk Model.

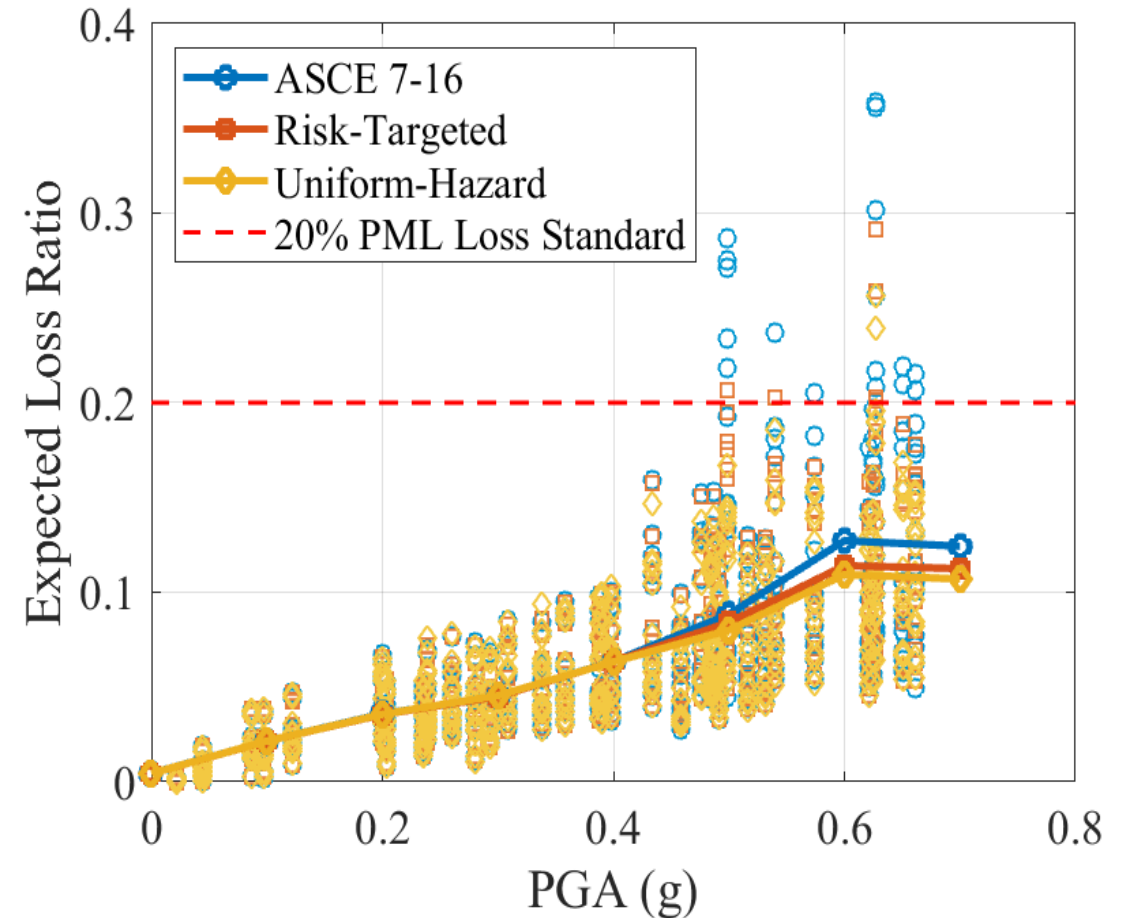


Expected Seismic Loss at Specific Hazard Levels

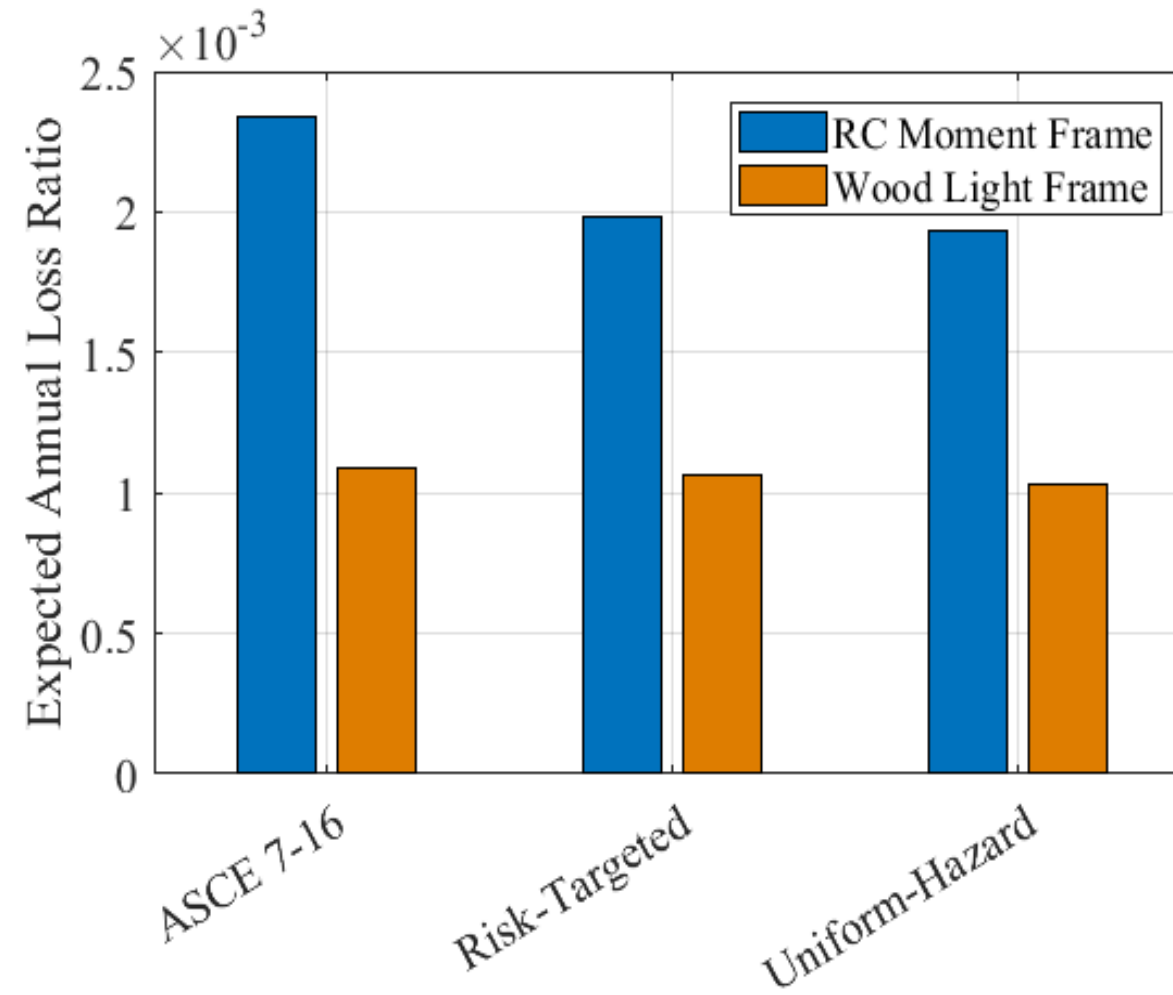
72 Year Return Period



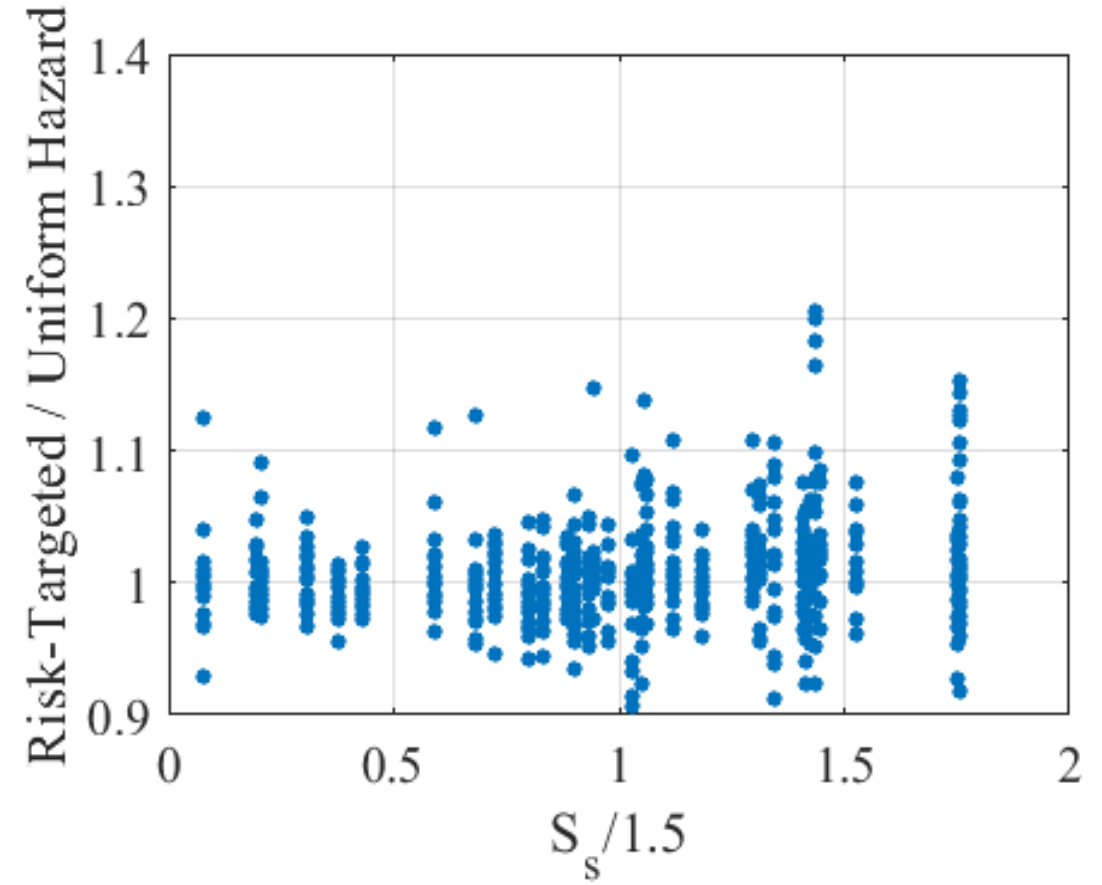
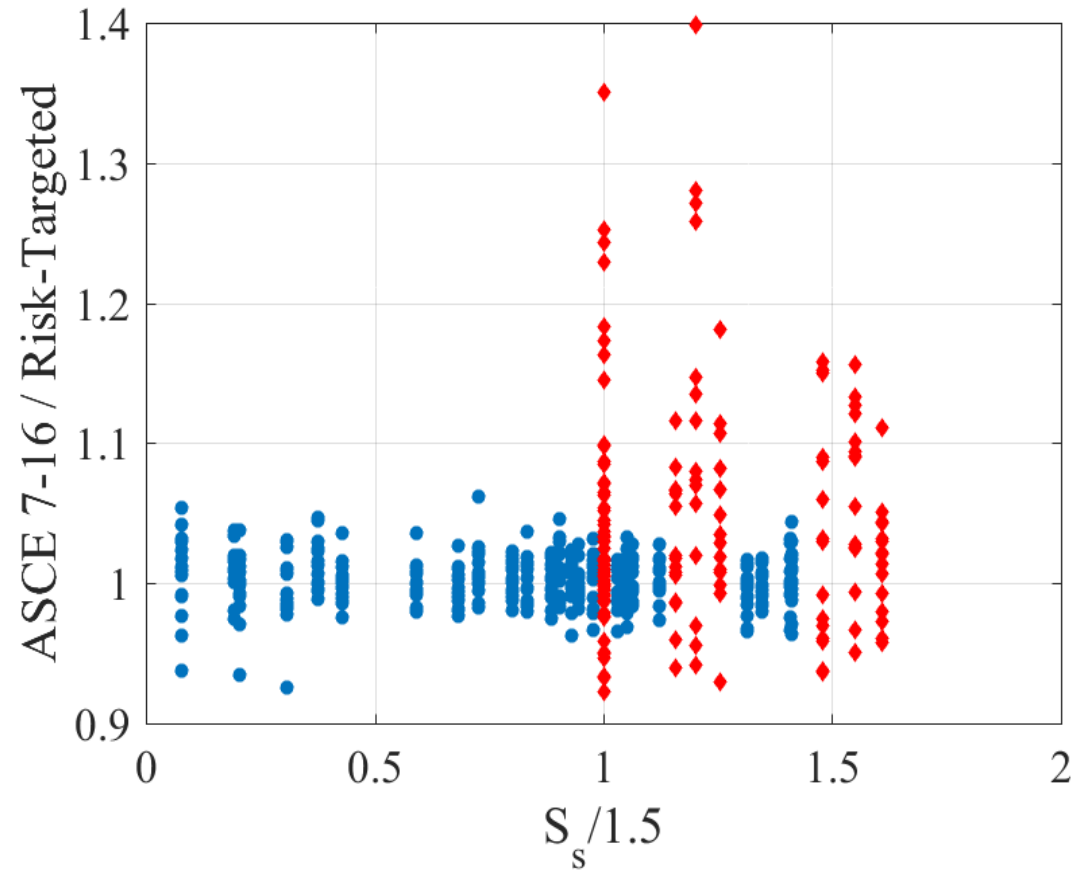
475 Year Return Period



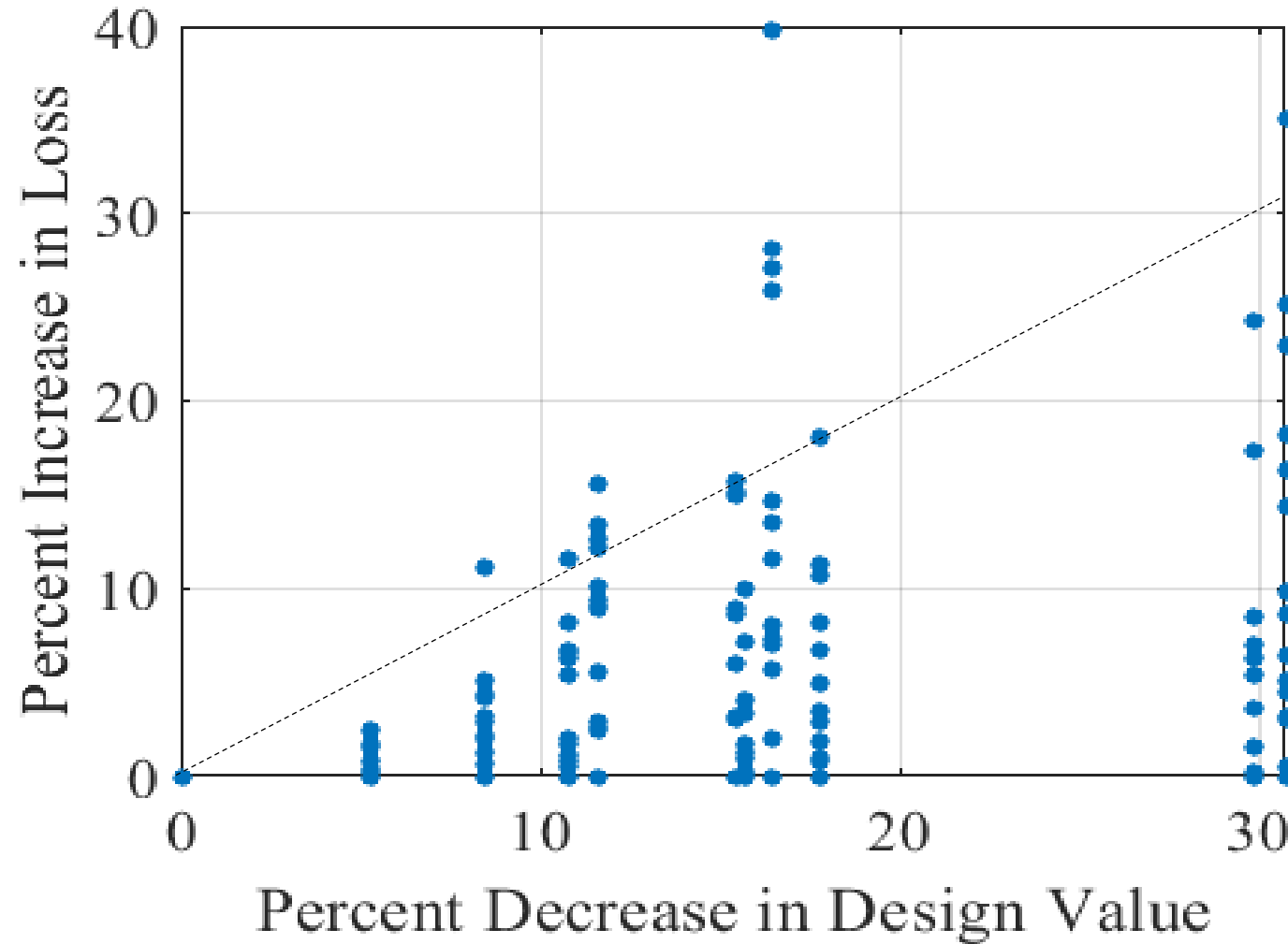
Expected Annualized Seismic Losses for Various Building Types



Ratio of Expected Annualized Seismic Losses



Change in Loss v Change in Design Value



Discussion

- Expected annual repair costs may be as much as 40% larger for buildings designed based on deterministic values in high hazard areas, as compared with designs using risk-targeted values at the same location.
- For a 4-story RC moment frame office in San Jose, CA, valued at \$10M, a 40% increase in expected loss over a 50 year lifespan would equate to around \$500,000 in extra expected repair costs, approximately 5% of the value of the building.
- Larger repair costs examined in this study come from design values that are as much as 30% smaller than the risk-targeted values.

Discussion

- Difference in loss between seismic design maps heavily depends upon:
 - Difference in the design value between the maps. The most significant differences occur in areas where the design is controlled by deterministic values.
 - The level of shaking, with larger levels of shaking seeing higher differences in loss.
 - The building's overstrength or sensitivity to design value changes.
- On average, losses based on a risk-targeted map tend to be similar to losses from a uniform-hazard map.

Thank You

For further questions, please contact Dustin at
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Special thanks to the Haselton Baker Risk Group for the use of the SP3-
Risk Model.