

Influence of ground motion duration on structural collapse risk

PEER Transportation Systems Research Program

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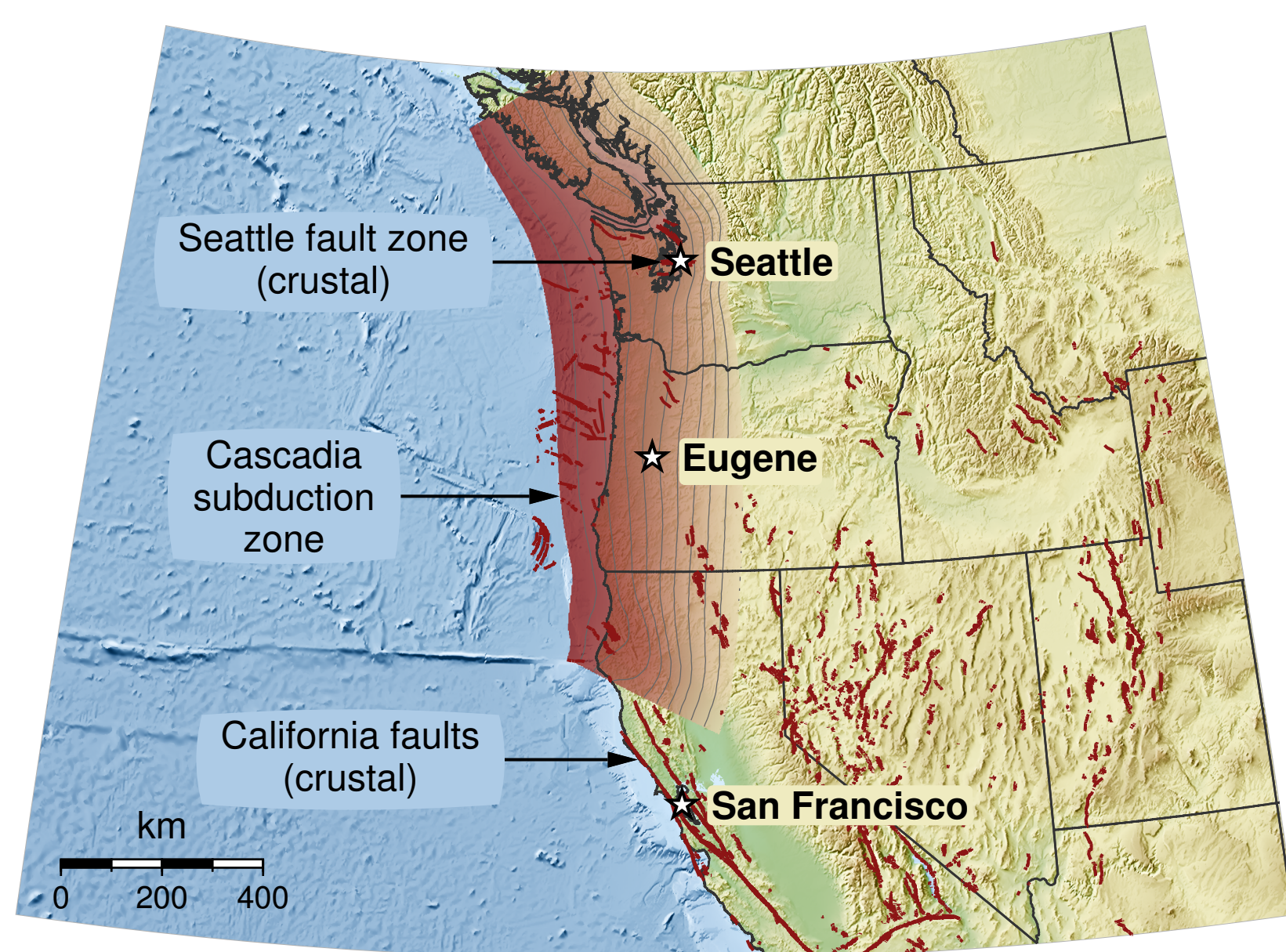
Background and Motivation

- Current standards and guidelines for ground motion selection focus only on response spectra; they do not explicitly consider duration
- Previous studies using spectrally equivalent long and short duration ground motions have demonstrated that ground motion duration does influence structural collapse capacity
- The effect of duration is attributed to the in-cycle and cyclic deterioration of structural strength and stiffness, and the ratcheting of drifts due to destabilizing $P - \Delta$ effects

Objectives

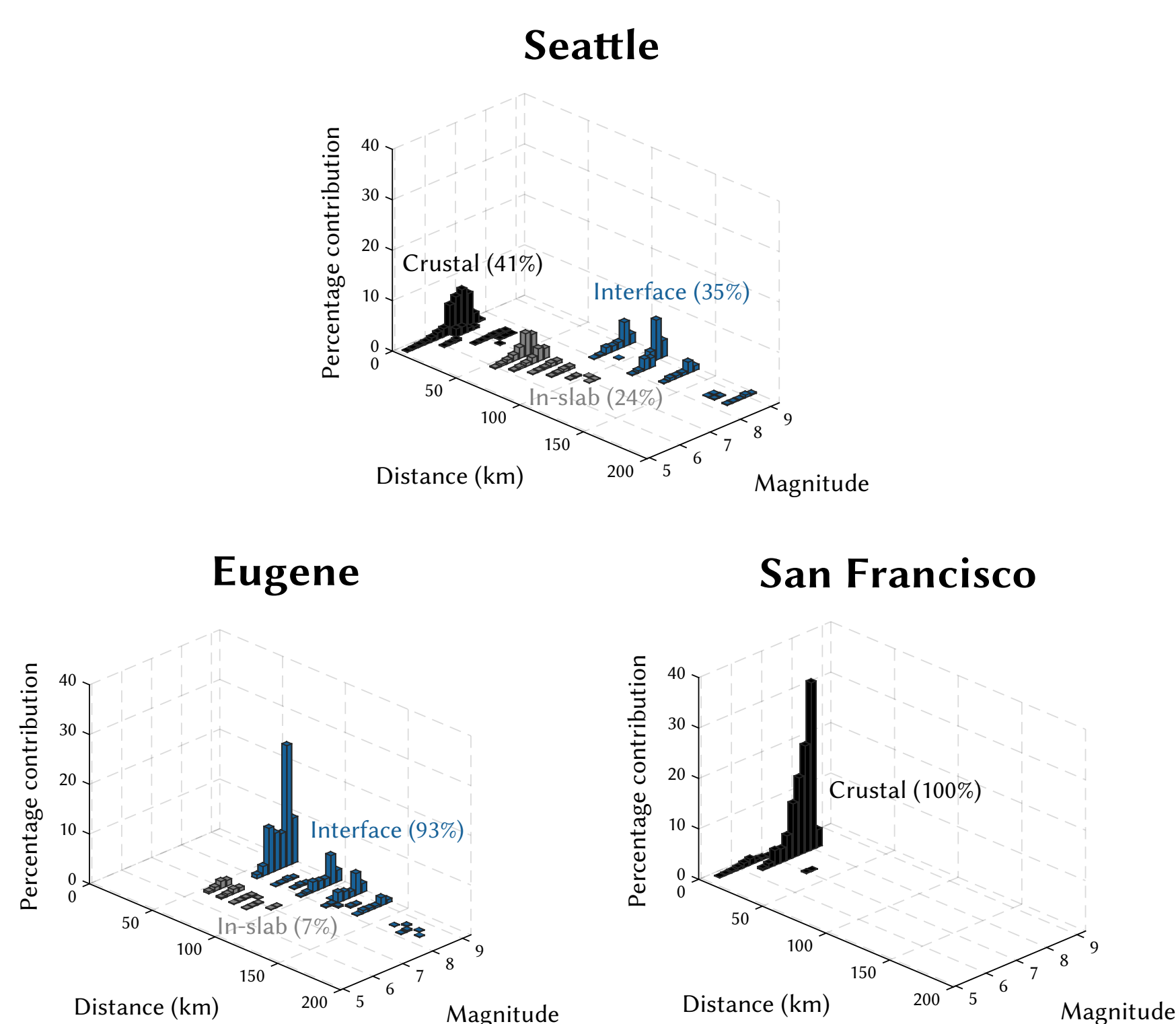
- Characterize seismic hazard in terms of the durations and response spectra of the anticipated ground motions
- Quantify the influence of ground motion duration on structural collapse risk at different sites
- Incorporate the effect of duration into structural performance assessment and design guidelines (*ongoing research*)

Chosen sites and seismic sources



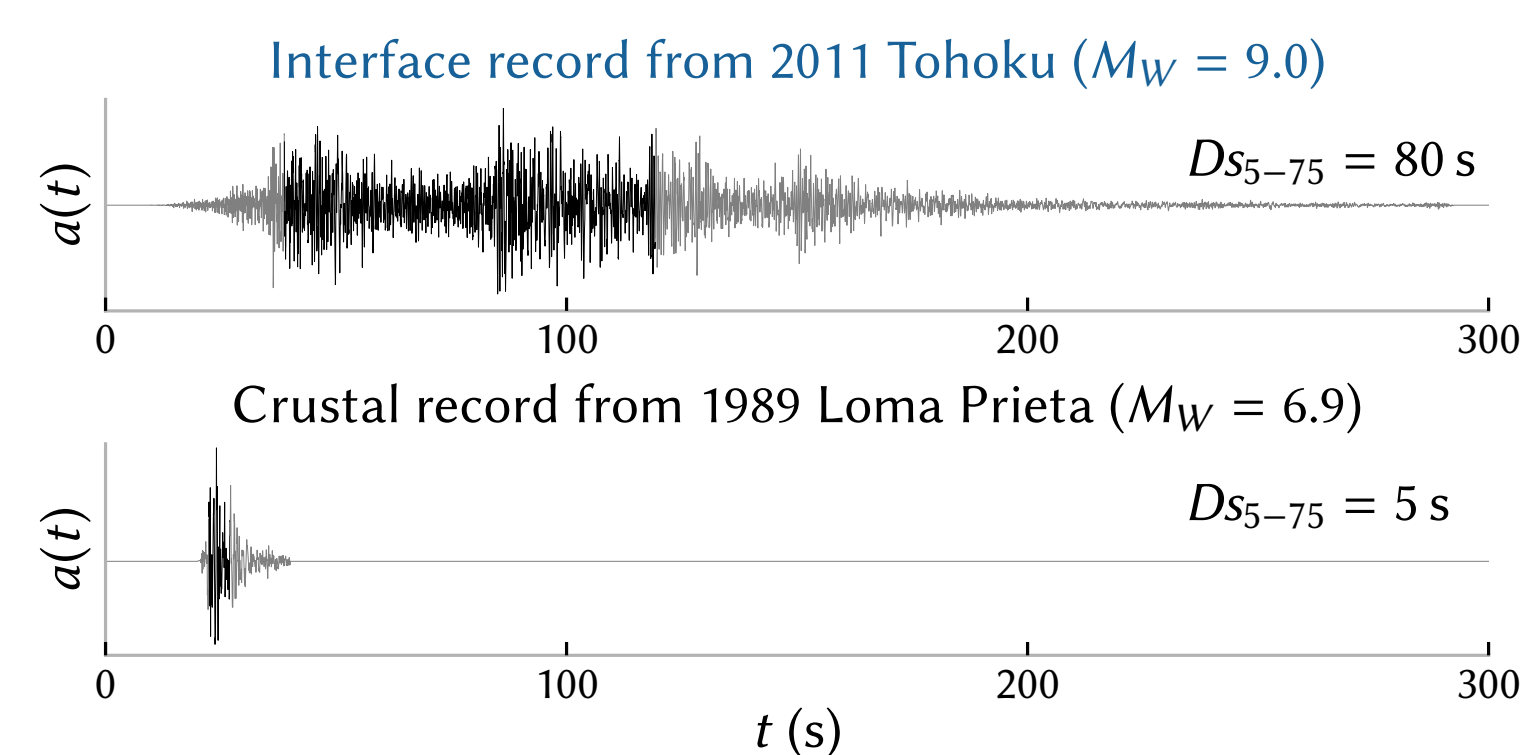
- The Cascadia subduction zone produces two types of earthquakes
 - Large magnitude *interface* earthquakes, e.g. 2011 Tohoku ($M_W = 9.0$)
 - Deep *in-slab* earthquakes, e.g. 2001 Nisqually ($M_W = 6.8$)

Seismic hazard deaggregation

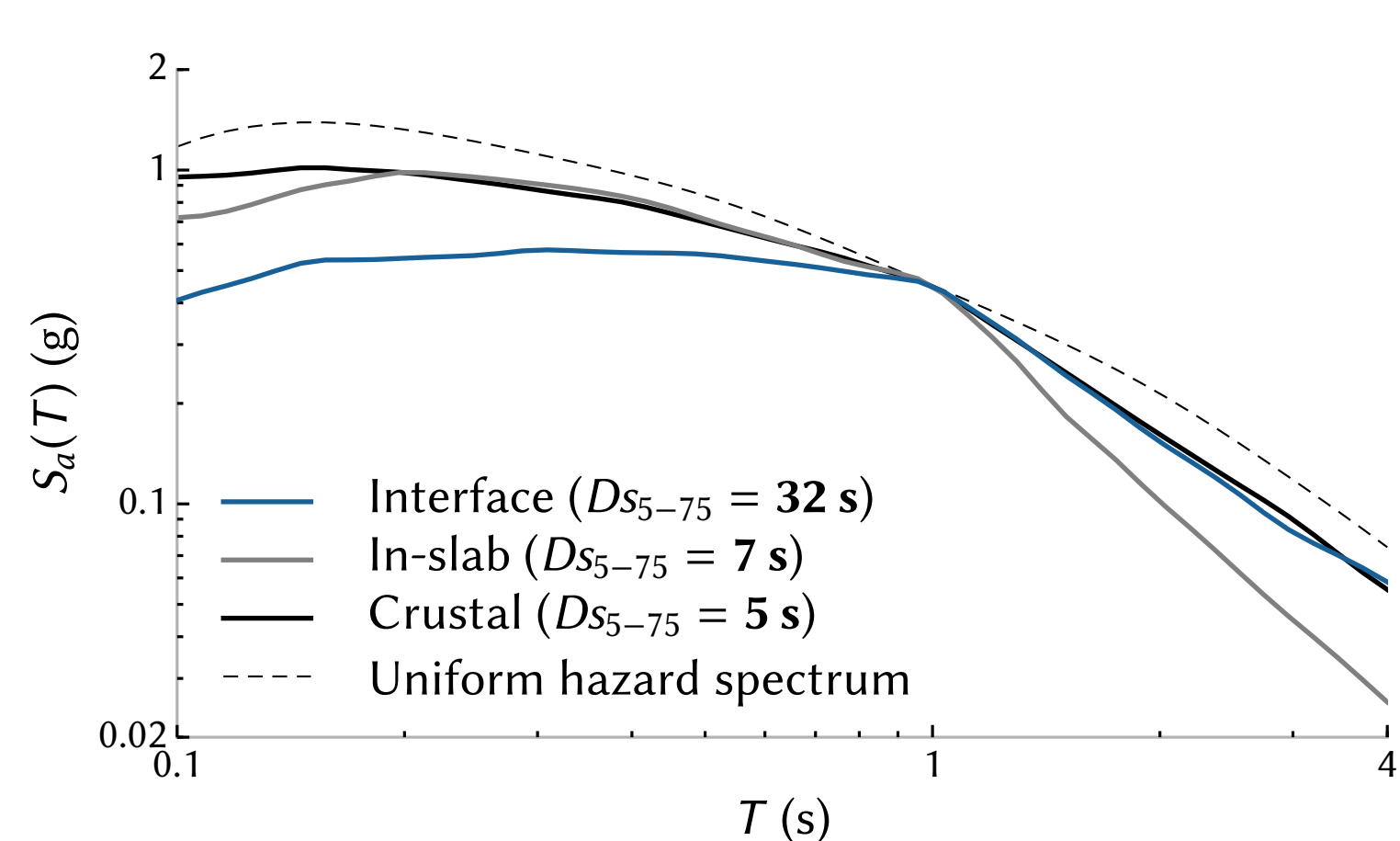


- Deaggregation results are conditional on the 2% in 50 year exceedance probability of $S_d(1s)$

Typical interface and crustal ground motions



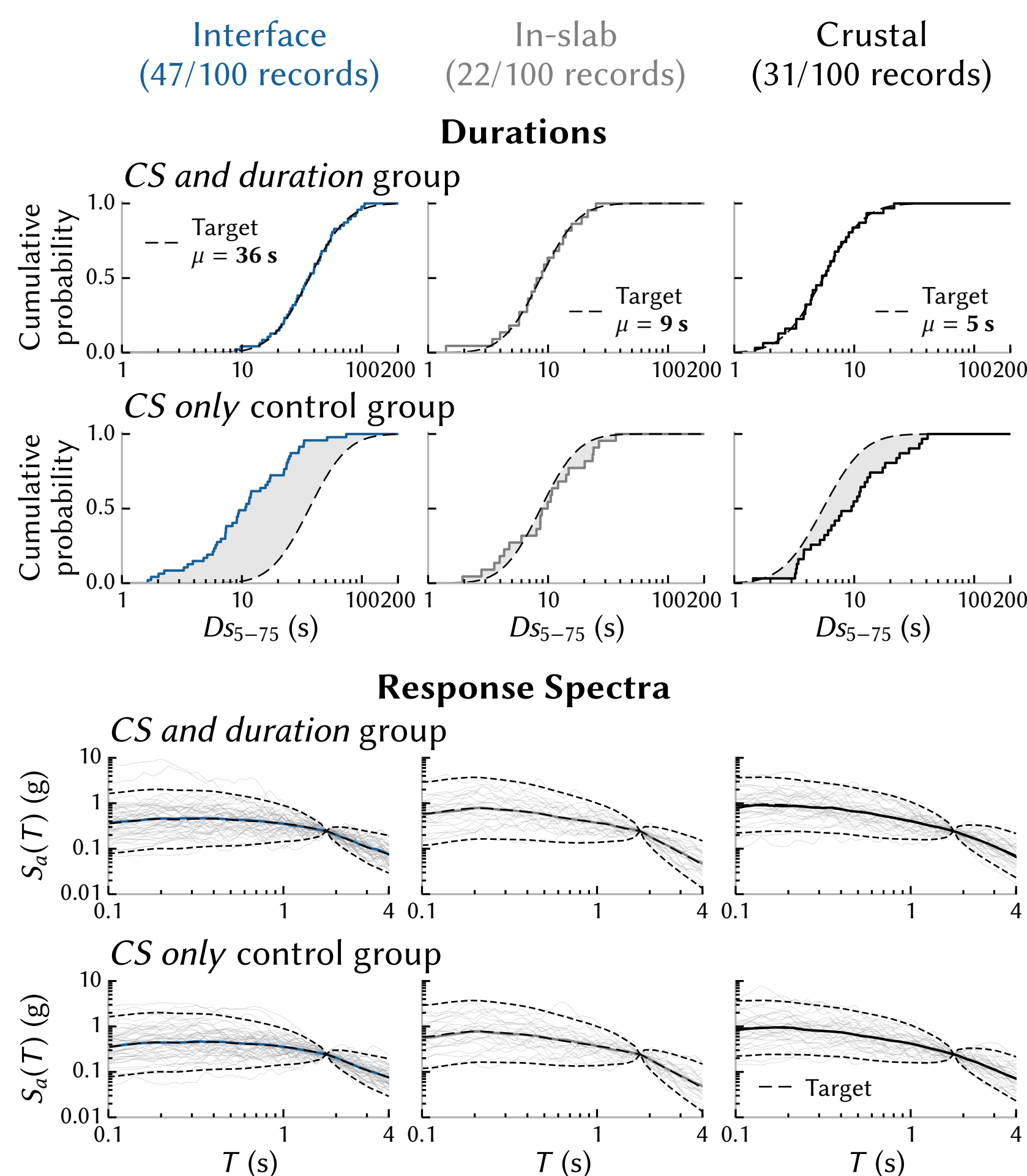
Median source-specific targets at Seattle



- Target distributions of 5-75% significant duration (D_{5-75}) are computed similar to a conditional spectrum using
 - deaggregation results
 - prediction equation for D_{5-75}
 - model for the correlation between the ϵ -values of D_{5-75} and $S_d(T^*)$

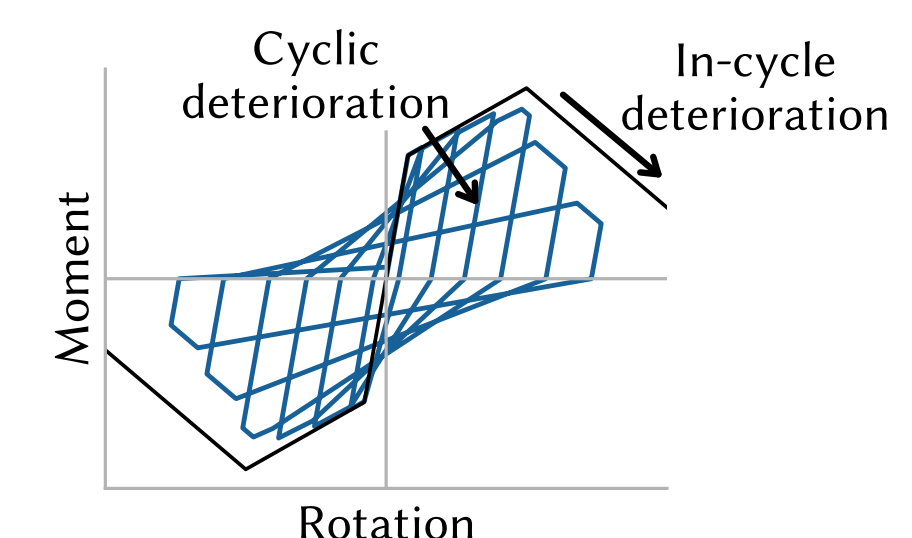
Ground motions selected for Seattle

- CS and duration group**
 - Selected to match duration and response spectrum targets
 - Interface records were selected from large magnitude earthquakes like 2011 Tohoku (Japan) and 2010 Maule (Chile)
 - In-slab and crustal records were selected from the PEER NGA database
- CS only control group**
 - Selected to match response spectrum targets only
 - All records were selected from the PEER NGA database
- Each group contains 8 sets of records chosen at different intensity levels; each set contains 100 records

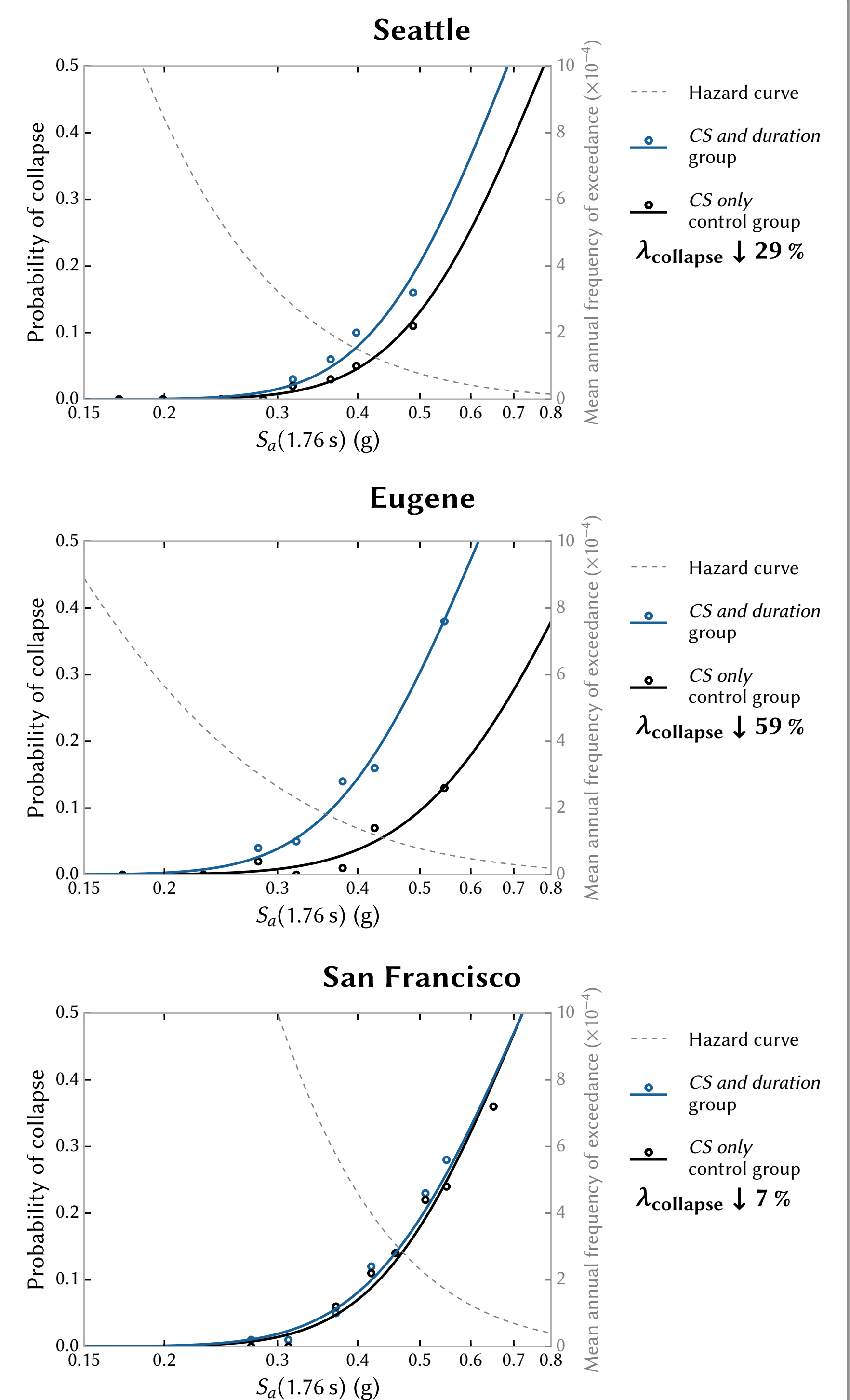


Structural model

- Eight-story reinforced concrete moment frame building, designed for a site in Seattle
- Concentrated plastic hinge model incorporates the in-cycle and cyclic deterioration of strength and stiffness, and destabilizing $P - \Delta$ effects



Collapse risk estimates



Conclusions

- Selecting ground motions from the PEER NGA database without considering their durations can lead to the unconservative underestimation of structural collapse risk at sites where the seismic hazard is dominated by large magnitude ($M_W \sim 9.0$) interface earthquakes
- This warrants the explicit consideration of ground motion duration, in a manner similar to response spectra, in structural performance assessment and design

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