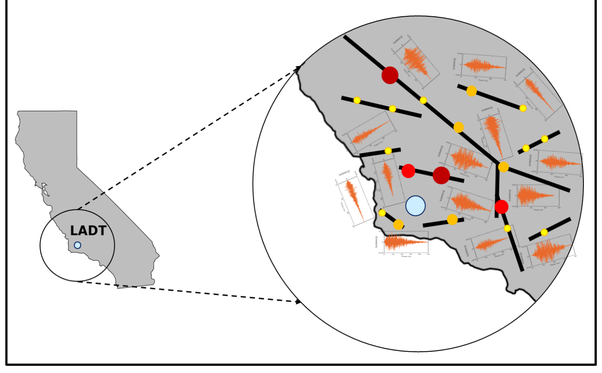
Validation and Utilization of Physics-Based Simulated Ground Motions for Bridge Performance Assessment

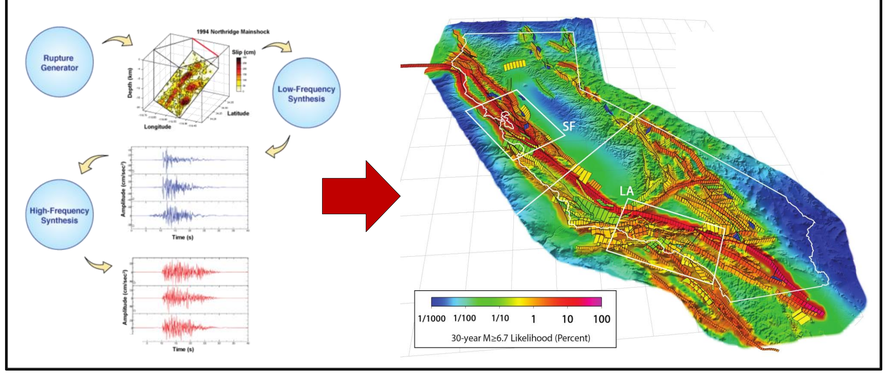
Investigators: Jawad Fayaz[1], Sarah Azar[2], Mayssa Dabaghi[2] and Farzin Zareian[1]
[1]**Department of Civil and Environmental Engineering, University of California, Irvine**
[2]**Department of Civil and Environmental Engineering, American University of Beirut, Lebanon**

Goal: Compare and Validate Simulated GMs against the Recorded GMs using statistical relationships between the corresponding Event parameters, RZZ parameters, and EDP of Bridge structures.

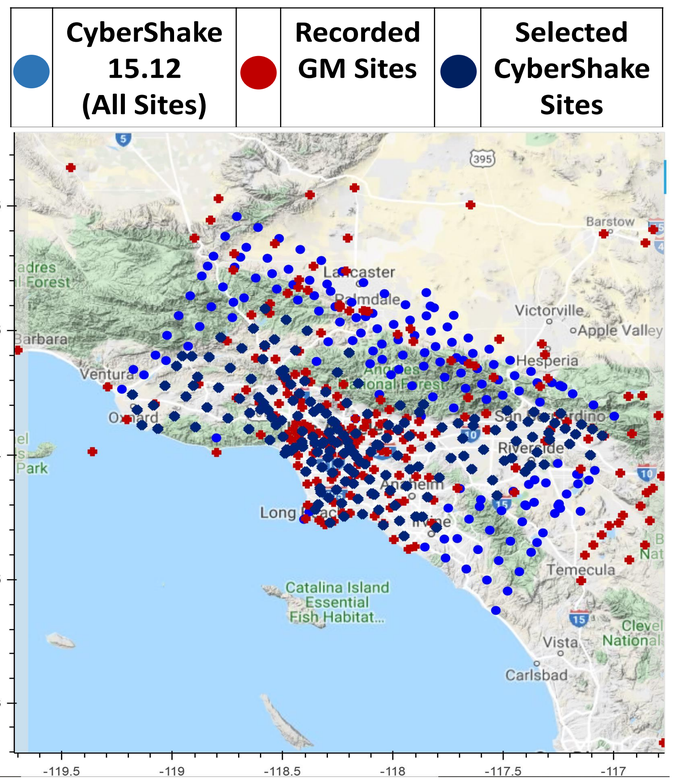
NGAWest2 Recorded GMs

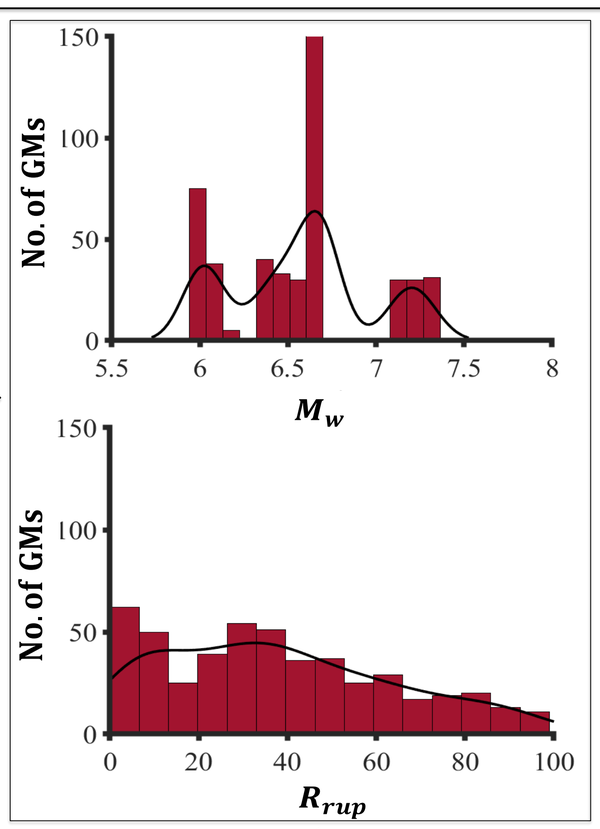


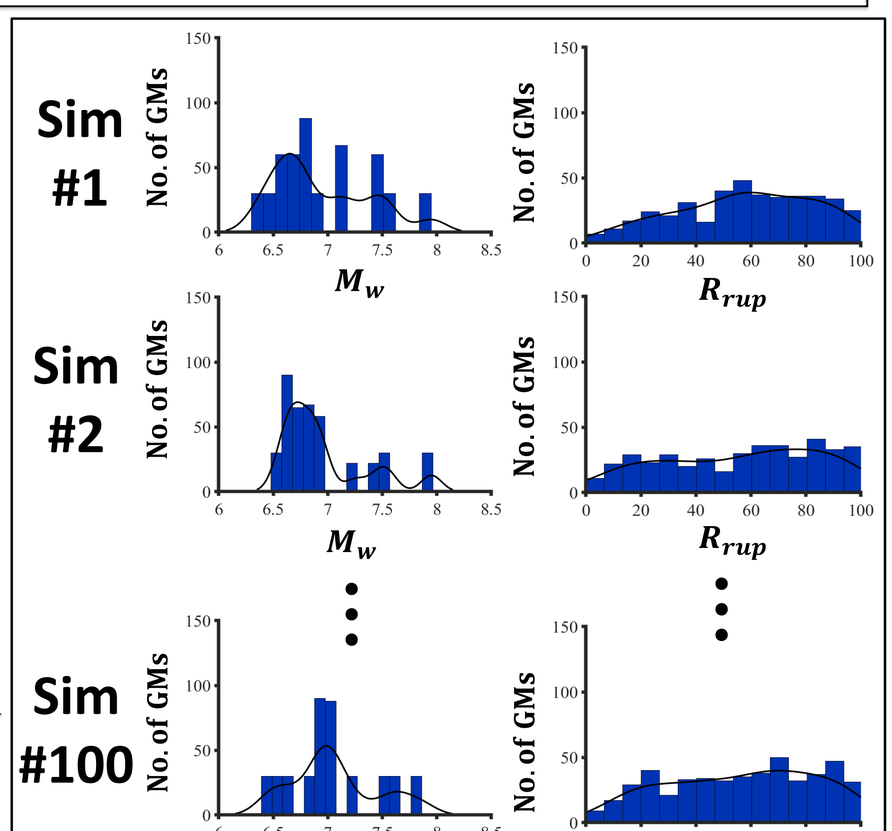
Physics-Based GMs (Cybershake 15.12)



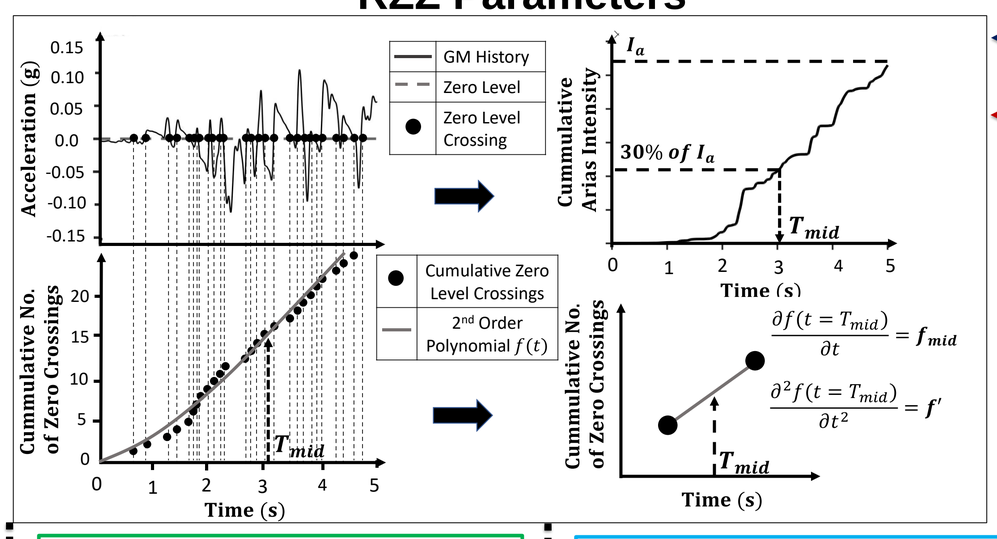
Event Parameters (M, R, V_{s30}) → **RZZ Parameters (I_a, f_{mid}, D_{5-95})** → **EDP$(Rot50CDR)$**



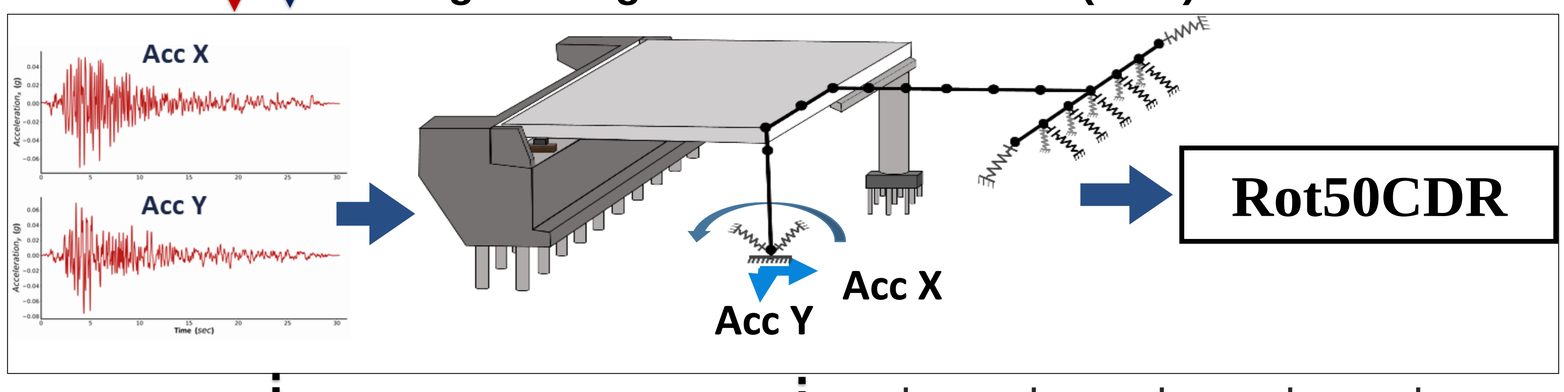




RZZ Parameters



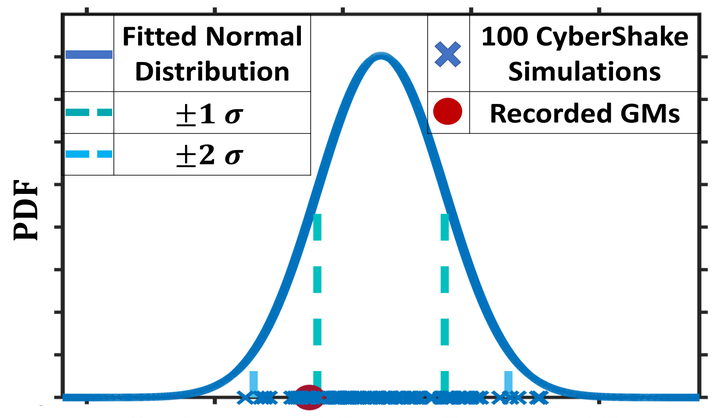
Engineering Demand Parameters (EDP)



$\ln(\widehat{RZZ}) = f_{mag} + f_{dis} + f_{flt} + f_{hng} + f_{site} + f_{sed} + f_{hyp} + f_{dip}$ — CB14 Form

$\ln(\widehat{EDP}) = f_{I_{a,maj}} + f_{I_{a,min}} + f_{f_{mid,maj}} + f_{f_{mid,min}} + f_{f'_{maj}} + f_{f'_{min}} + f_{T_{mid,maj}} + f_{T_{mid,min}}$ — Linear Regression

$\ln(\widehat{EDP}) = f_{mag} + f_{dis} + f_{flt} + f_{hng} + f_{site} + f_{sed} + f_{hyp} + f_{dip}$ — CB14 Form



EDP	Bias	$f_{I_{a,maj}}$	$f_{I_{a,min}}$	$f_{f_{mid,maj}}$	$f_{f_{mid,min}}$	$f_{f'_{maj}}$	$f_{f'_{min}}$	$f_{D_{5-95,maj}}$	$f_{D_{5-95,min}}$
$\pm 1\ \sigma$	✗	✓	✓	✓	✗	✓	✗	✓	✓
$\pm 2\ \sigma$	✓	✓	✓	✓	✓	✓	✓	✓	✓

EDP	Bias	f_{mag}	f_{dis}	f_{site}	f_{sed}	f_{hyp}
$\pm 1\ \sigma$	✓	✓	✗	✓	✓	✓
$\pm 2\ \sigma$	✓	✓	✓	✓	✓	✓

$I_{a,maj}$	Bias	f_{mag}	f_{dis}	f_{hng}	f_{site}	f_{sed}	f_{hyp}
$\pm 1\ \sigma$	✓	✓	✓	✓	✗	✗	✓
$\pm 2\ \sigma$	✓	✓	✓	✓	✗	✓	✓

$f_{mid,maj}$	Bias	f_{mag}	f_{dis}	f_{hng}	f_{site}	f_{sed}	f_{hyp}
$\pm 1\ \sigma$	✓	✓	✓	✓	✓	✗	✗
$\pm 2\ \sigma$	✓	✓	✓	✓	✓	✓	✓

$D_{5-95,maj}$	Bias	f_{mag}	f_{dis}	f_{hng}	f_{site}	f_{sed}	f_{hyp}
$\pm 1\ \sigma$	✗	✗	✗	✓	✗	✗	✓
$\pm 2\ \sigma$	✓	✓	✓	✓	✓	✗	✓

$f'_{mid,maj}$	Bias	f_{mag}	f_{dis}	f_{hng}	f_{site}	f_{sed}	f_{hyp}
$\pm 1\ \sigma$	✗	✗	✗	✓	✓	✓	✗
$\pm 2\ \sigma$	✓	✓	✗	✓	✓	✓	✓

Conclusions:

1. RZZ parameters can be too stringent to perform validation of simulated ground motions.
2. Relations between the Event parameters and EDP, and RZZ parameters and EDP for recorded and simulated GMs tend to be statistically similar.

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