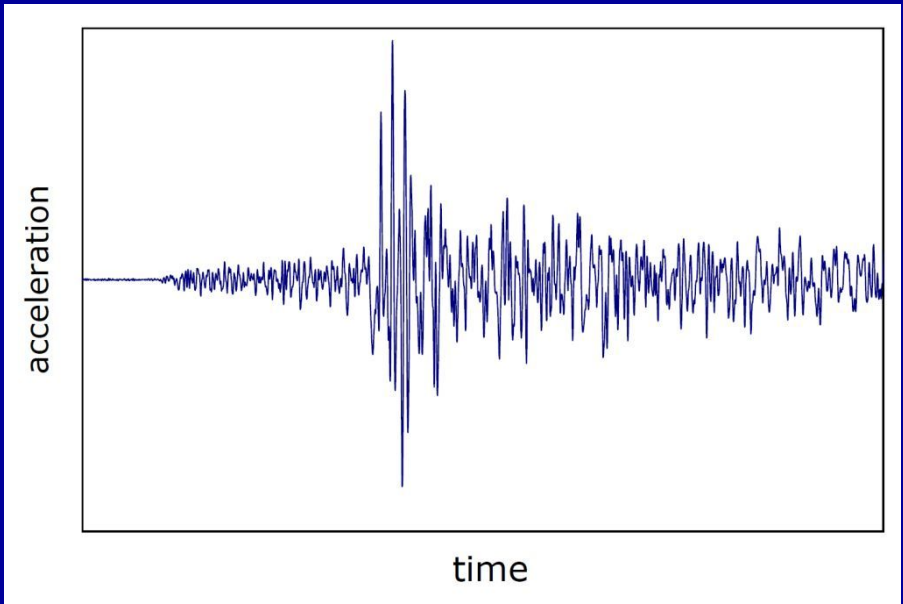
LESSONS LEARNED FOR GROUND MOTION PREDICTION EQUATION DEVELOPMENT FROM NGA WEST



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Objectives

- Perform statistical goodness-of-fit analyses to compare the prediction accuracy of the ground motion prediction equations developed from the NGA (Next Generation Attenuation) project
  - Tests on subsets of the NGA database used during model development
  - Tests on data from recent earthquakes not present in the databases used to develop the models (*blind comparison tests*)
- Compare the NGA relations with previous ground motion prediction equations (GMPEs) on the blind comparison tests
  - 2004 **M** 6.0 Parkfield, California, earthquake
  - 2003 **M** 6.5 San Simeon, California, earthquake
- Compare the models' performance in various situations:
  - Mainshocks vs. aftershocks
  - Small, intermediate, and large distances
  - Soil vs. rock sites

GMPEs tested in this study

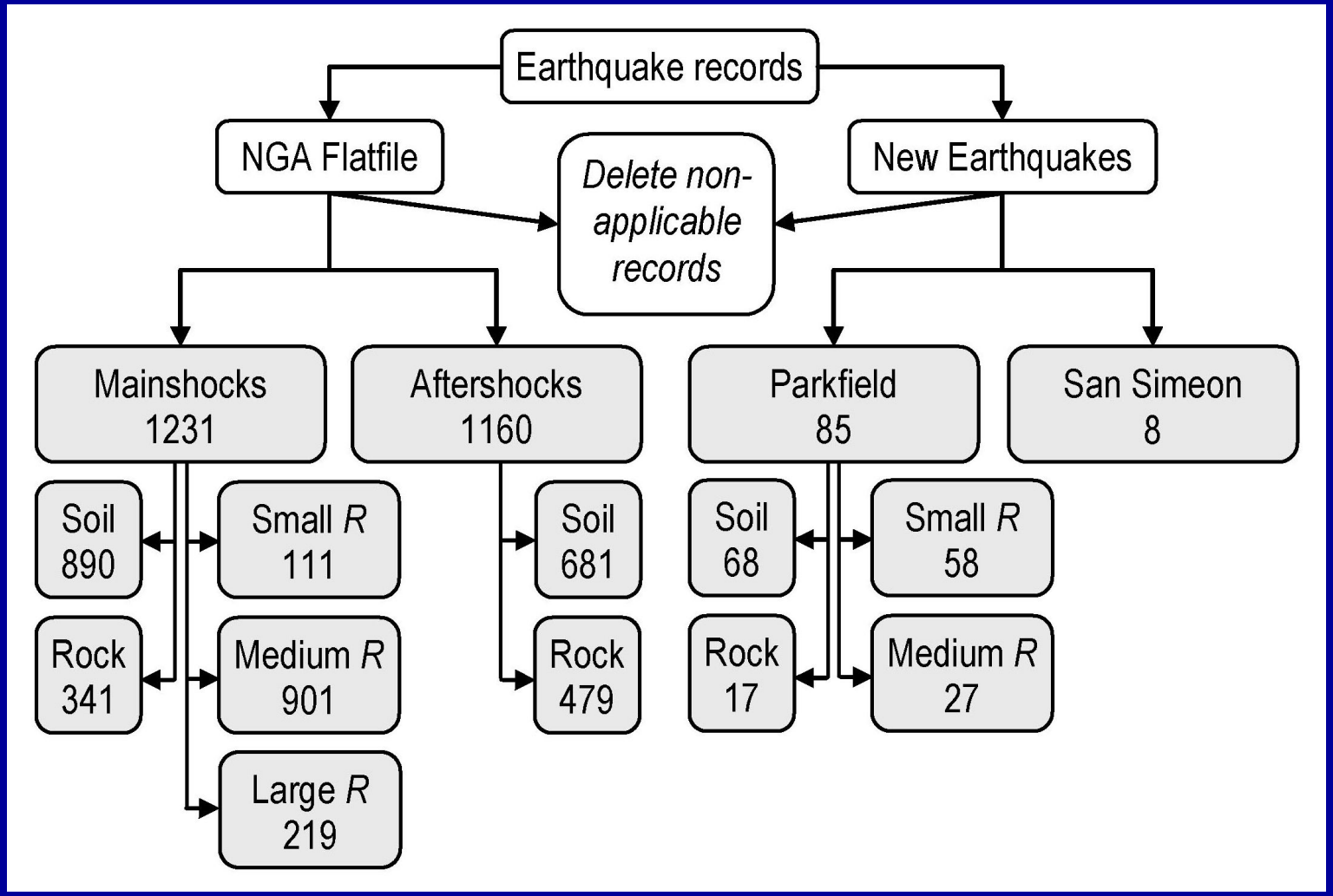
NGA MODELS

Team	Year	Abbrev.
Abrahamson and Silva	2008	AS08
Boore and Atkinson	2008	BA08
Campbell and Bozorgnia	2008	CB08
Chiou and Youngs	2008	CY08
Idriss	2008	I08

PREVIOUS MODELS

Team	Year	Abbrev.
Abrahamson and Silva	1997	AS97
Boore, Joyner, and Fumal	1997	BJF97
Campbell	1997	C97
Sadigh, Chang, Egan, Makdisi, and Youngs	1997	SCE97
Idriss	1991	I91

Testing subsets



V_{S30} (m/s): **Soil**, $180 \leq V_{S30} < 450$. **Rock**, $450 \leq V_{S30} \leq 1300$.

Distance (km): **Small**, $R \leq 10$. **Medium**, $10 < R \leq 100$. **Large**, $100 < R \leq 200$.

Goodness-of-fit measures

- Nash-Sutcliffe model efficiency coefficient (*E*)
  - More sensitive to differences between model predictions and observations than other typical goodness-of-fit measures
  - Takes on values between -∞ and 100%
  - Values less than 0 indicate that the arithmetic mean of the observed values has greater prediction accuracy than the model
- *E* is computed over the set of the following ground motion parameters in this study:

PGA	Sa (0.5 sec)
Sa (0.1 sec)	Sa (1.0 sec)
Sa (0.2 sec)	Sa (2.0 sec)
Sa (0.3 sec)	

$$E = \left[1 - \frac{\sum_{i=1}^{N}\left(Y_i - \hat{Y}_i\right)^2}{\sum_{i=1}^{N}\left(Y_i - \bar{Y}\right)^2}\right] \cdot 100\%$$

Results for mainshocks

		NGA models				
		AS08	BA08	CB08	CY08	I08
Division 1	Soil	57.7	59.5	60.4	53.7	–
	Rock	49.7	55.6	57.2	23.5	43.4
Division 2	Small *R*	22.6	34.8	35.4	–11.8	–
	Medium *R*	46.4	46.9	48.9	38.4	–
	Large *R*	–6.5	15.3	23.8	3.5	–
Total *E*		54.8	58.1	59.3	42.7	–
Model rankings based on total *E*		3	2	1	4	–

Results for aftershocks

		NGA models				
		AS08	BA08	CB08	CY08	I08
Divisions	Soil	51.2	49.8	44.6	45.8	–
	Rock	25.6	39.2	28.6	30.9	37.4
Total *E*		47.9	47.6	41.2	43.1	–
Model rankings based on total *E*		1	2	4	3	–

Results for Parkfield earthquake

		NGA models					*Previous models*				
		AS08	BA08	CB08	CY08	I08	AS97	BJF 97	C97	SCE 97	I91
Division 1	Soil	36.6	34.7	42.0	24.3	–	34.7	40.0	32.7	31.6	–
	Rock	43.1	44.7	41.1	30.3	40.9	8.7	44.4	19.1	15.1	26.8
Division 2	Small *R*	23.0	20.7	26.7	5.2	–	11.6	25.6	11.4	9.1	–
	Medium *R*	65.0	70.5	74.9	75.9	–	75.2	75.6	73.8	74.3	–
Total *E*		38.1	36.9	42.0	25.8	–	30.4	41.1	30.1	28.4	–
Model rankings based on total *E*		3	4	1	8	–	5	2	6	7	–

Results for San Simeon earthquake

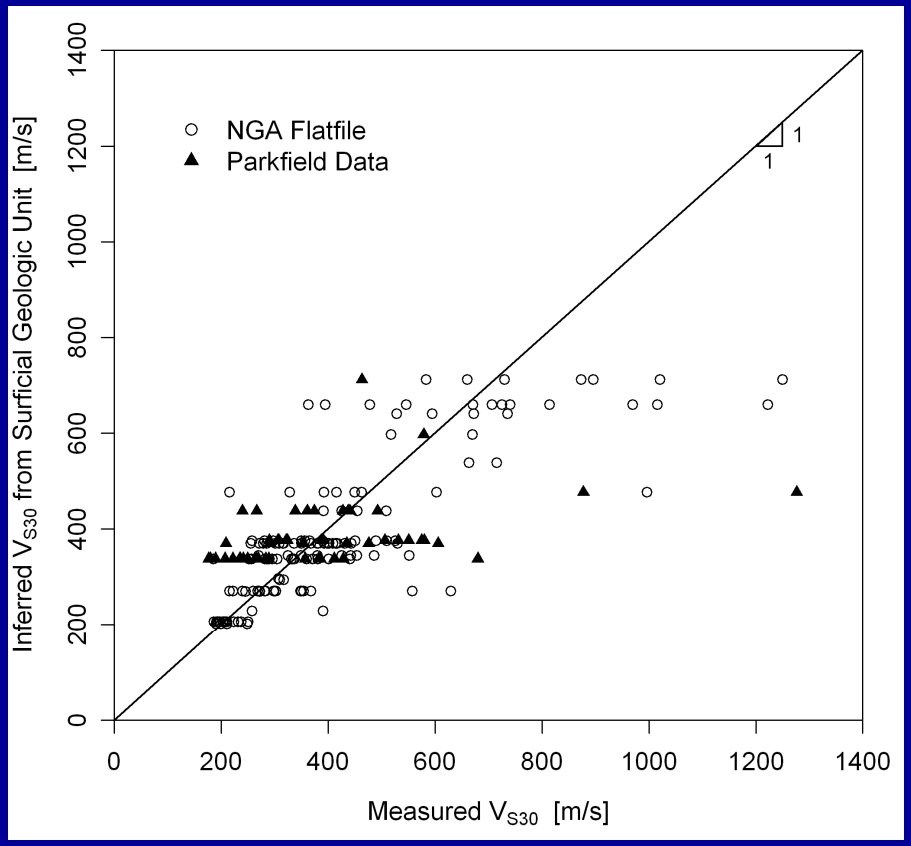
	NGA models					*Previous models*				
	AS08	BA08	CB08	CY08	I08	AS97	BJF97	C97	SCE97	I91
Total *E*	66.2	67.0	66.2	70.3	–	55.5	58.8	49.2	34.0	–
Model rankings based on total *E*	3 (tie)	2	3 (tie)	1	–	6	5	7	8	–

Observations

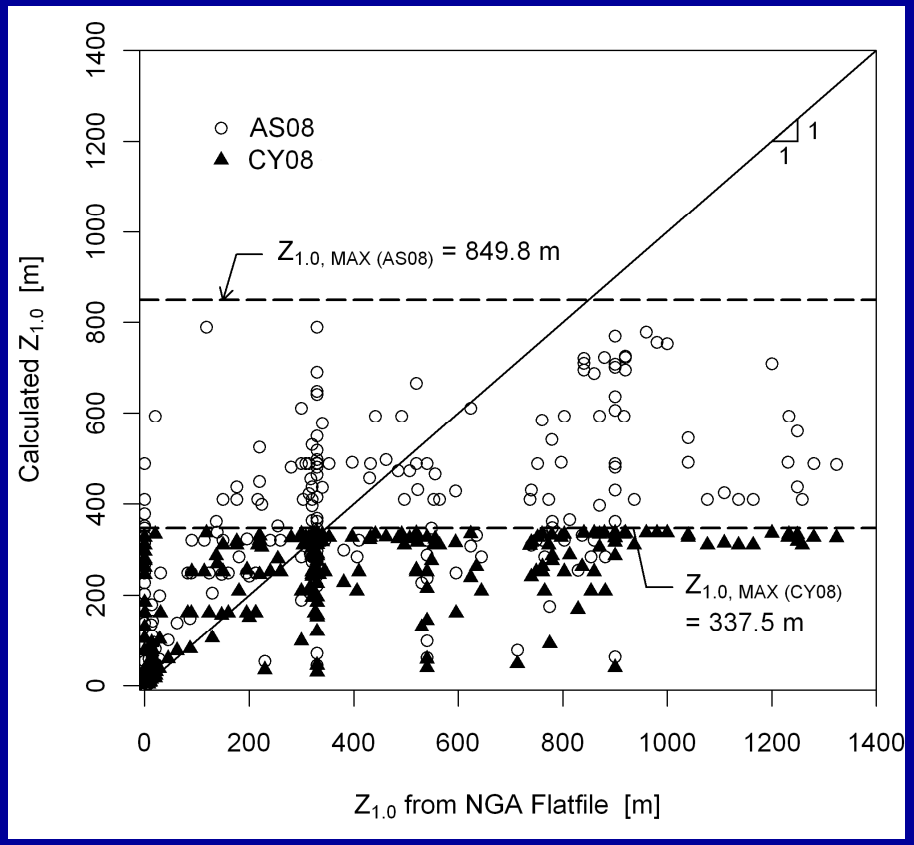
- Inclusion of ground motion records from aftershocks in model development may decrease the prediction accuracy of mainshocks
- Best prediction accuracy occurs at intermediate distances, with models consistently obtaining higher coefficients of efficiency
- The over-fitting of GMPEs to specific distance regimes decreases their prediction accuracy outside of those ranges

Observations

Measured vs. Predicted V_{S30}



Measured vs. Predicted $Z_{1.0}$



- Site parameters (such as V_{S30} and depth parameter, $Z_{1.0}$) show large discrepancies between observed and predicted values

Conclusions

- Increased model complexity does not necessarily lead to increased prediction accuracy
- Inclusion of large amounts of ground motion records from specific earthquakes or distance regimes may lead to over-fitting
- A higher-quality regression dataset (not necessarily higher-*quantity*), with greater measurements of site characteristics, coupled with simple functional forms in the GMPEs, may yield the best solution
- Proper sharing of modeling information for NGA East will aid users in implementing and understanding the models

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