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Ground Motion Evaluation Procedures for Performance-Based Design

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Framework for PBD

$$\upsilon(DV) = \iint G\langle DV \mid DM \rangle \mid dG\langle DM \mid IM \rangle \| d\upsilon(IM) \|$$

DV = Decision variable (e.g., down time, costs)
DM = Damage measure (e.g., peak ductility, cumulative hysteretic energy dissipated)
IM = Intensity measure (e.g., S_a, duration)
$\upsilon(IM)$ = rate of exceedance of *IM*

Role of Ground Motion Evaluation

Factors Affecting $\upsilon(IM)$:

- $\upsilon(m)$: Rate of earthquakes with magnitude m
- $f(m)$: relative likelihood of earthquakes with different magnitudes
- $f(IM|m,r)$: distribution of IM conditioned on m and r

Report Chapters

1: Introduction

2: Source Characterization

3: Ground Motion Attenuation Relations

4: Characteristics of Near-Fault Ground Motions

5: Site Effects

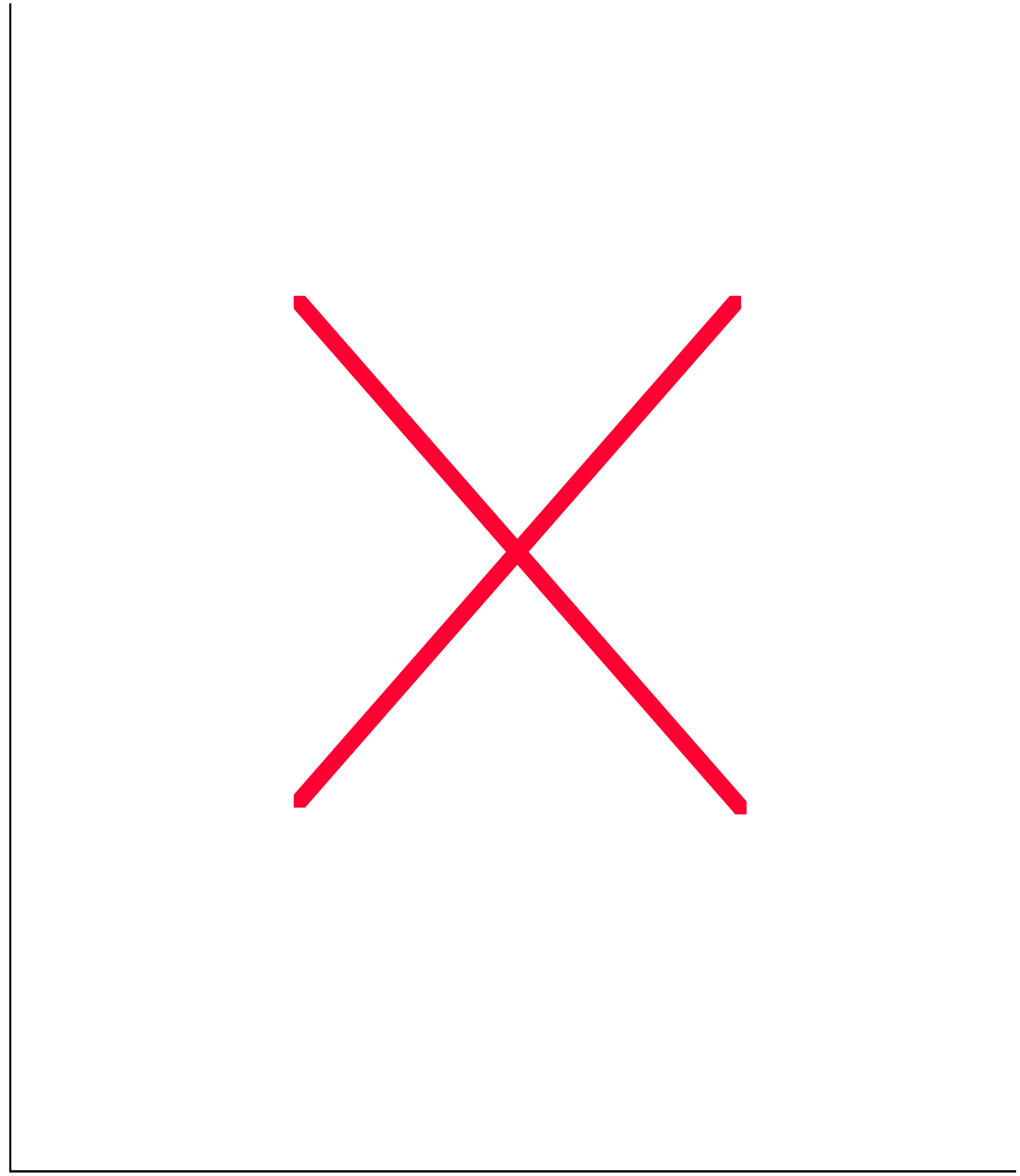
6: Ground Motion Simulation

7: Time History Selection

8: Conclusions

Source Characterization

- Source locations
  - _Segmentation
  - _*m-A* relations
- *f(m)* models
- Rate
  - _Large (characteristic) events
  - _Small events

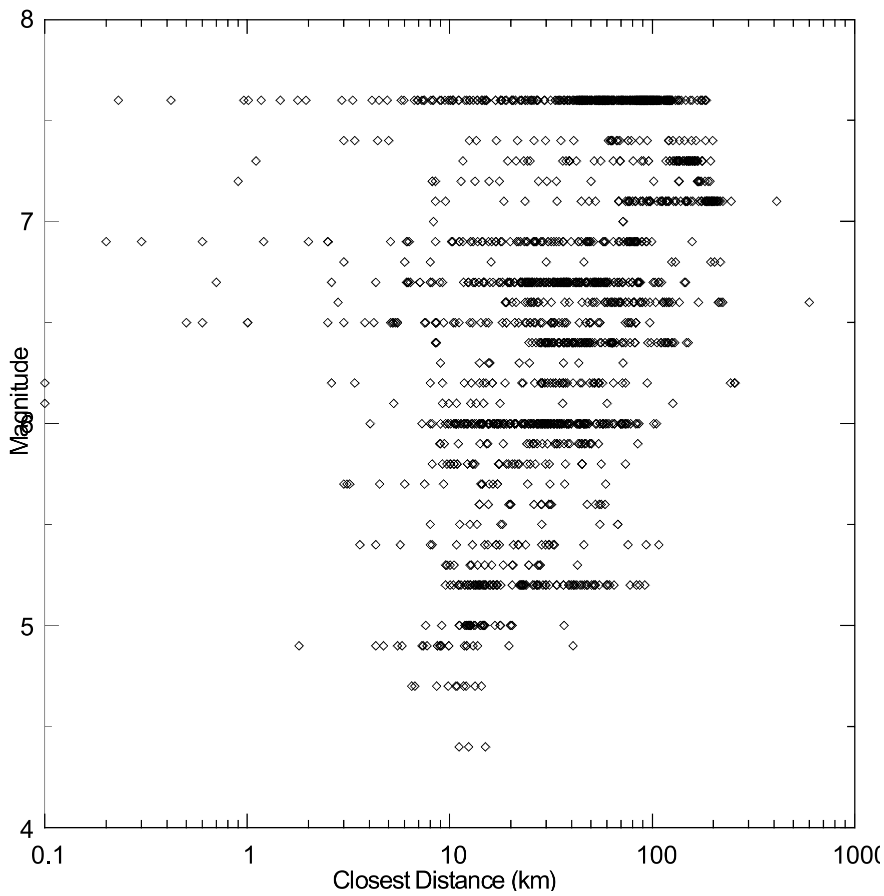


Source: WGCEP, 1999

Attenuation Relationships

f(IM|m,r):

- Established from observation
- Data limitations:
  - Few data for large *m*, small *r*
  - Uneven distribution across events



Attenuation Relationships

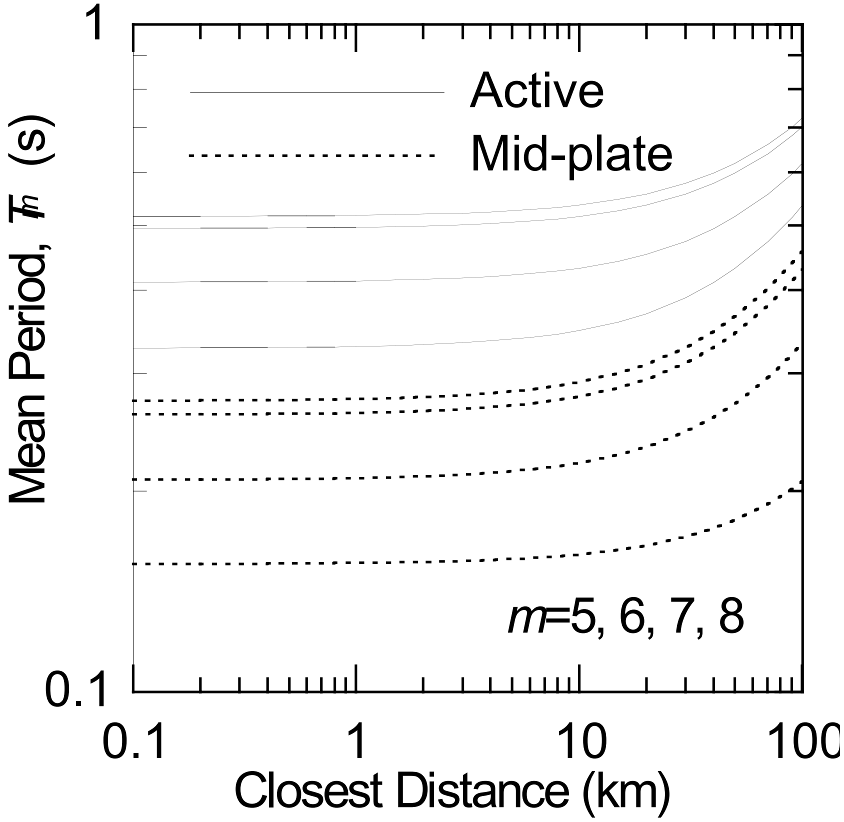
Factors affecting attenuation of S_a:

- m, r
- Tectonic regime
- Focal mechanism
- Site condition
- Other factors (e.g., Moho bounce, surface fault rupture)

Attenuation Relationships

IM's other than S_a:

- Peak velocity
- Vertical spectra
- Arias intensity
- Duration
- No. of cycles
- Mean period



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Attenuation Relationships

- Vector hazard

$$\upsilon(DV) = \iint G\langle DV \mid DM \rangle \mid dG\langle DM \mid IM \rangle \| d\upsilon(IM) \mid$$

- Requires: $f(IM_1, IM_2|m,r)$
- Evaluated from correlation of residuals $(\varepsilon_1,\varepsilon_2)$

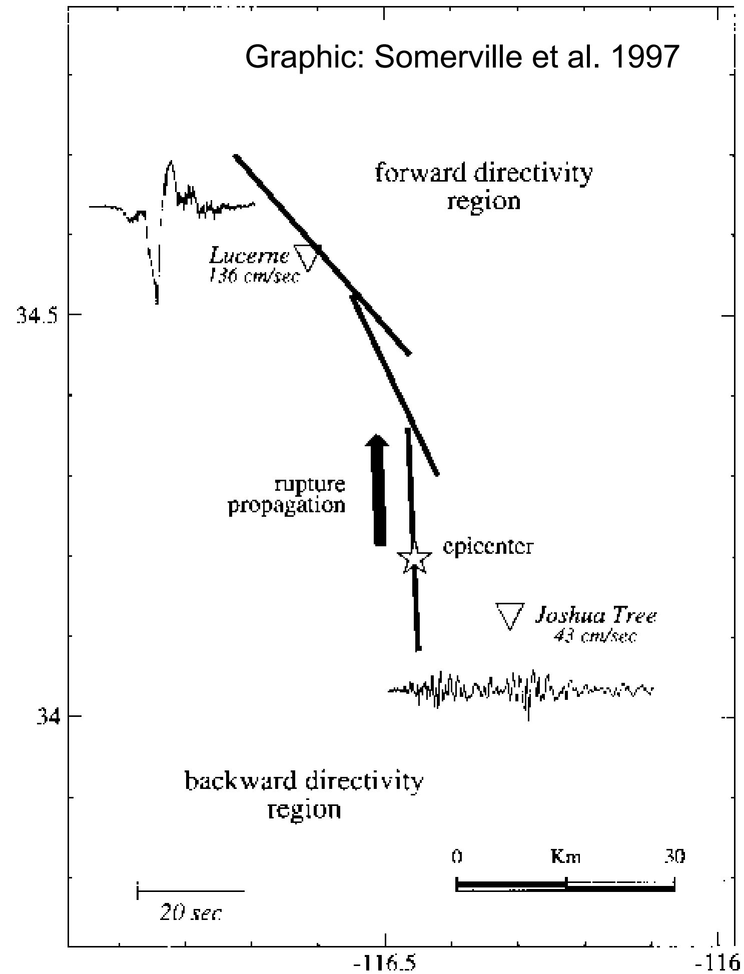
Limitations of Attenuation Relations

- Quantified in term of bias and standard error
- Near-fault ground motions
- Site effects

Near-Fault Ground Motions

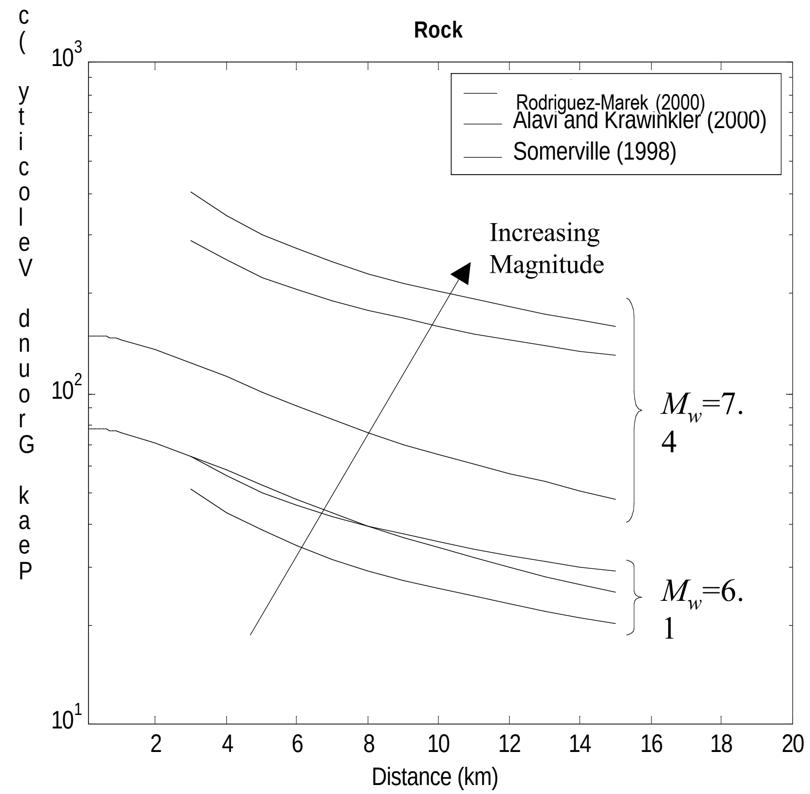
<u>Rupture Directivity</u>

- Forward/backward regions
- Polarized in strike-normal direction
- Occurs for *r* < 20-60 km, *m* > 6.0-6.5



Directivity Models

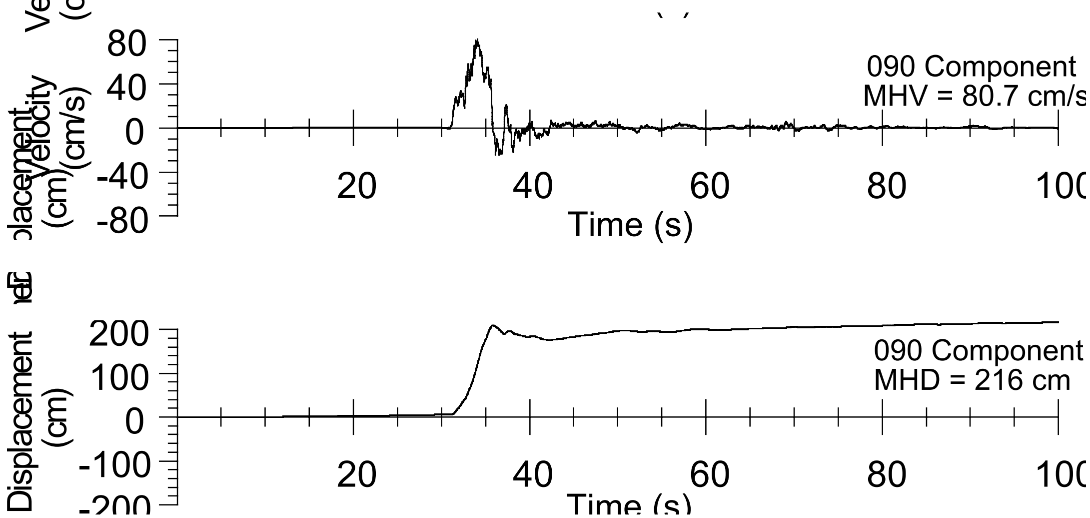
- Attenuation corrections for S_a, duration, N
- Independent relations for PGV, pulse period (T_v), number of significant pulses



Near-Fault Ground Motions

Fling-Step Effect

- Permanent ground deformation
- Polarized in slip-parallel direction
- Model development needed



Rathje et al., 2000

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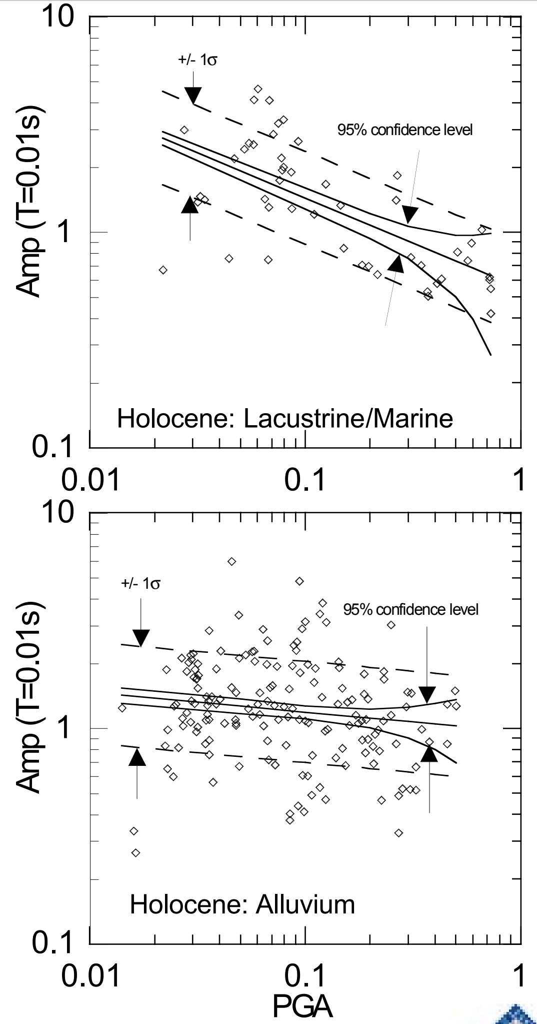
Site Effects

- Ground response
  - Response of flat sediment layers
  - Accounts for resonance, impedance contrasts, sediment non-linearity
- Basin response
  - Accounts for 2-D/3-D sediment geometry
  - Defined by IM deviations from ground response predictions
- Surface topography

Observational Studies

- Amplification as function of:
  - Surface geology
  - 30-m V_s
  - Geotechnical conditions
  - Basin parameters
- Amplification relative to:
  - Hard rock sites
  - Weathered "California" rock



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Conclusions

- Source characterization
- IM's given
  - Site location relative to source
  - *m*, site condition
- Large uncertainties