Distance Extension of GMPEs

NGA East TI Team

Workshop 3C

June 17-18, 2015

Need for Distance Extensions

- Product of study to be GMPEs for R_{RUP} 0 to 1500 km
- Developers may have provided GM values for either R_{RUP} or R_{JB} for distance ranges smaller than 0 to 1500 km
- Conversion from R_{JB} to R_{RUP} may have introduced undesirable behavior at small R_{RUP} values

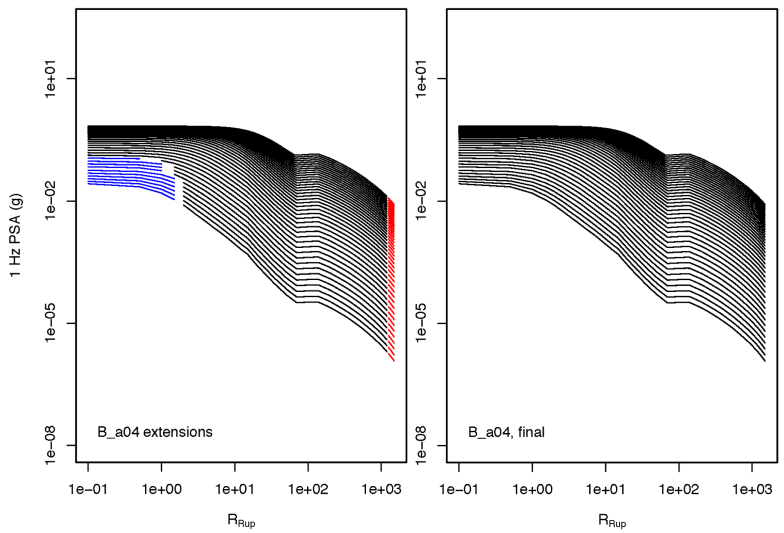
Basic Process

- Fit ground motion values provided by developers with an appropriate functional form
- Use fitted model to extend distance range of ground motion values after scaling to match predictions at edge of developers' values
- Perform fit for individual magnitudes
- Impose constraints on magnitude scaling specified by developers
- Check with developers that extension is reasonable

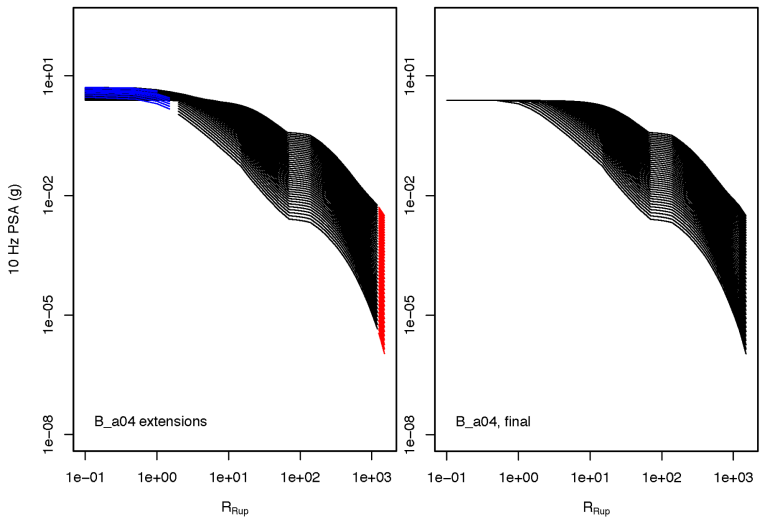
Functional Forms

- Extension to large distance
  - $\ln PSA = C_1 + C_2 \ln R + C_3 R$
  - For some models, fix C_2 at -0.5
- Extension to small distances
  - $\ln PSA = C_1 + C_2 \ln(R + C_3)$ Form 1
  - $\ln PSA = C_1 + C_2 \ln[(R^2 + h^2)^{1/2}]$ Form 2
  - Select form that best matched predictions

Example: a Boore Model for 1 Hz



Example: a Boore Model for 10 Hz



Boore Models

- Conversion from R_{JB} to R_{RUP} produces negative magnitude scaling at small values of RRUP in both original data and extended data
- Imposed full saturation at very short distances using the predicted motions for **M** 8

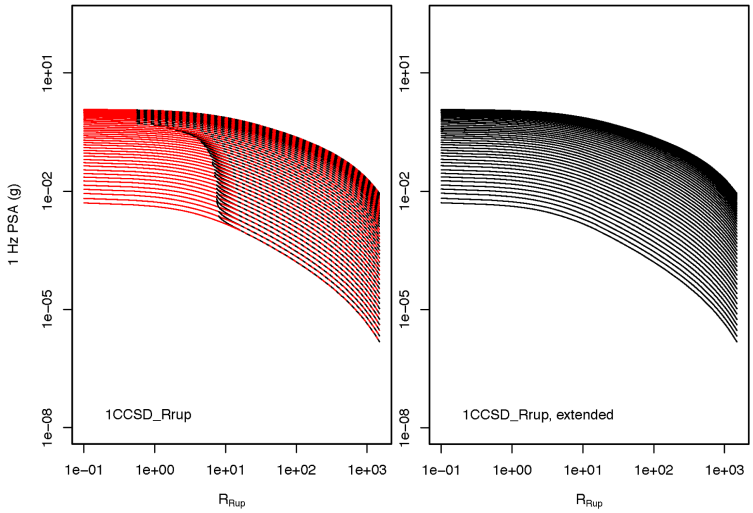
Darragh et al Models

- Fit entire distance range using

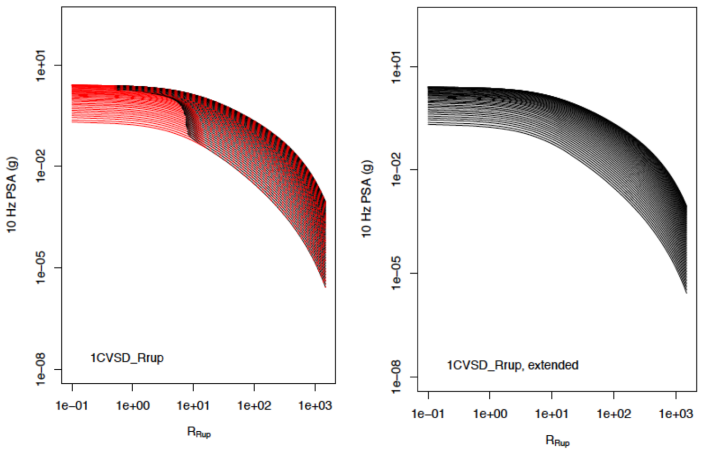
$$\ln PSA = C_1 + C_2 \ln(R + C_3) + C_4 R$$

- Extrapolate to small RRUP ignoring upward curvature introduced by conversion from R_{JB} to R_{RUP}

Darragh et al for 1 Hz



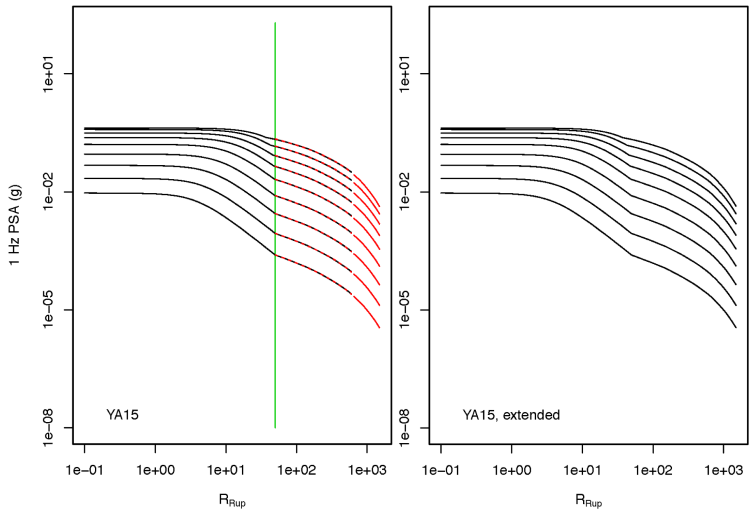
Darragh et al at 10 Hz



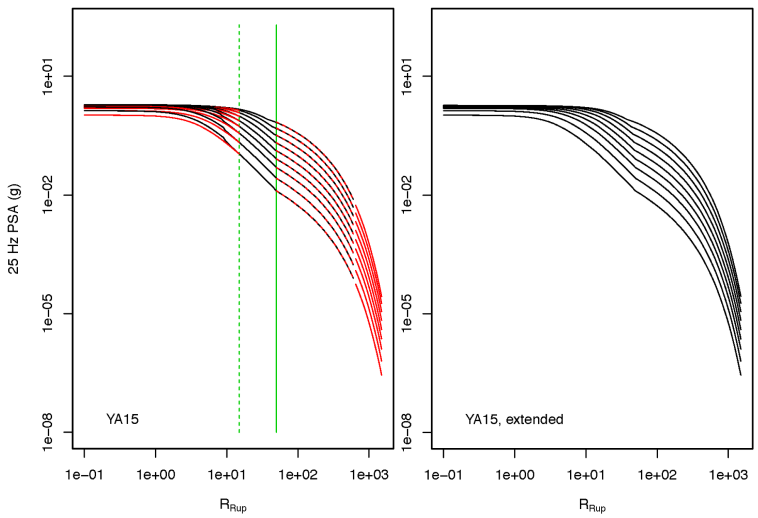
Yenier and Atkinson

- Standard extension to large distances
- For frequencies above 20 Hz conversion from RJB to RRUP introduced steps at small distances
  - Removed by using the distance scaling and relative magnitude scaling for 20 Hz motions

YA at 1 Hz



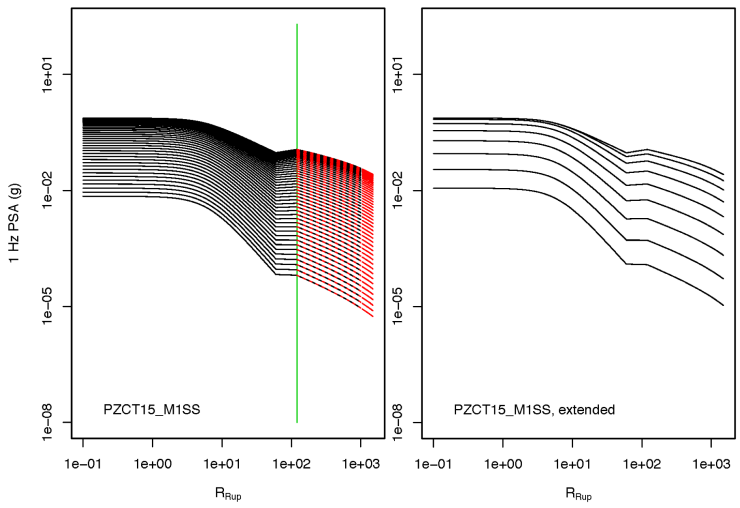
YA15 at 25 Hz



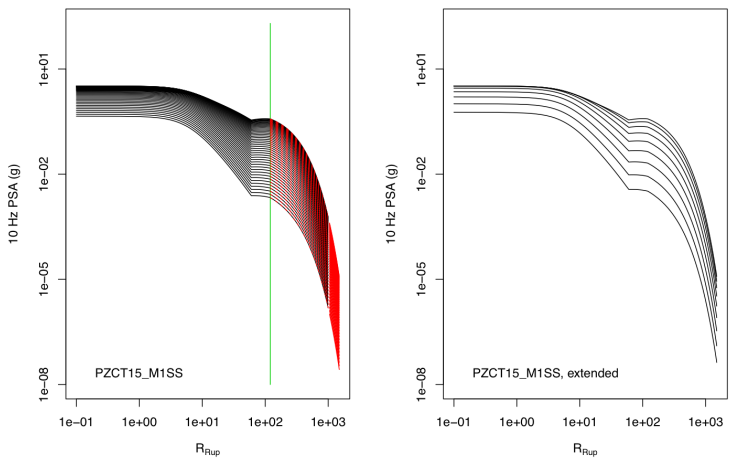
PZCT15

- Large distance extension using standard form
- Conversion from RJB to RRUP introduced some oversaturation at higher frequencies
  - Selected magnitude that produced highest estimate at very short distances
  - Starting with this magnitude, $PSA(M_{i+1}, R) \geq PSA(M_i, R)$

PZCT at 1 Hz



PZCT15 at 10 Hz



Functional Forms

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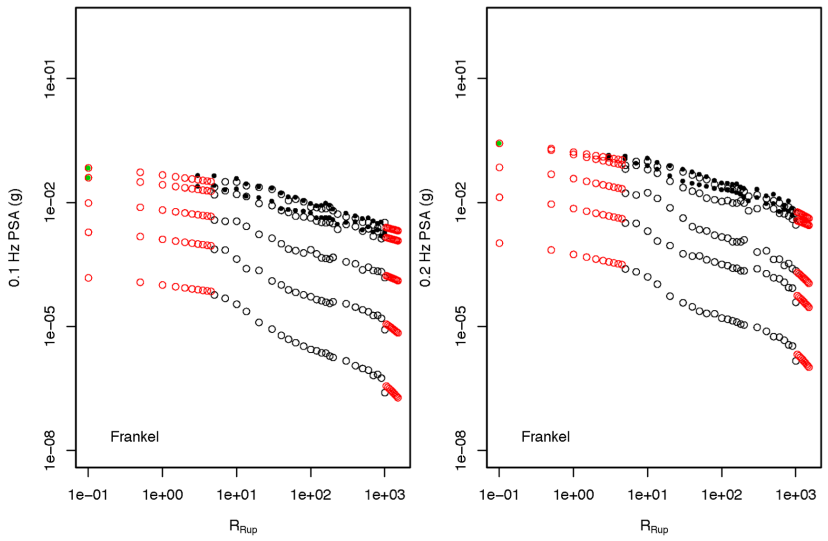
- Extension to small distances
  - $\ln PSA = C_1 + C_2 \ln(R + C_3)$ Form 1
  - $\ln PSA = C_1 + C_2 \ln[(R^2 + h^2)^{1/2}]$ Form 2
  - Select form that best matched predictions

Frankel

- Large distance extension
  - Use standard form with C_2 fixed to -0.5
- At short distances fit with form 2 with very small *h* to obtain nearly linear fit with ln(R)
  - If value at R 0 For **M** 7.5 > for **M** 8 refit with constraint they are equal
  - For **M** < 7.5 use relative amplitude at R_{RUP} = 5 to scale motions for R_{RUP} < 5 from **M** 7.5 motions

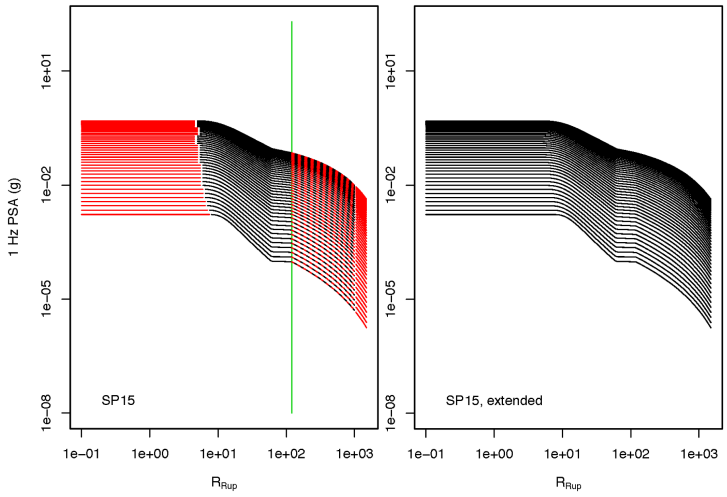
Frankel Extrapolations



SP15

- Large distances used standard form
- Short distances
  - Predictions reach a "maximum" at R_{RUP} slightly less than 10 km
  - extended estimates from shortest distance provided to R_{RUP} = 0 with no increase in amplitude

SP15 Example



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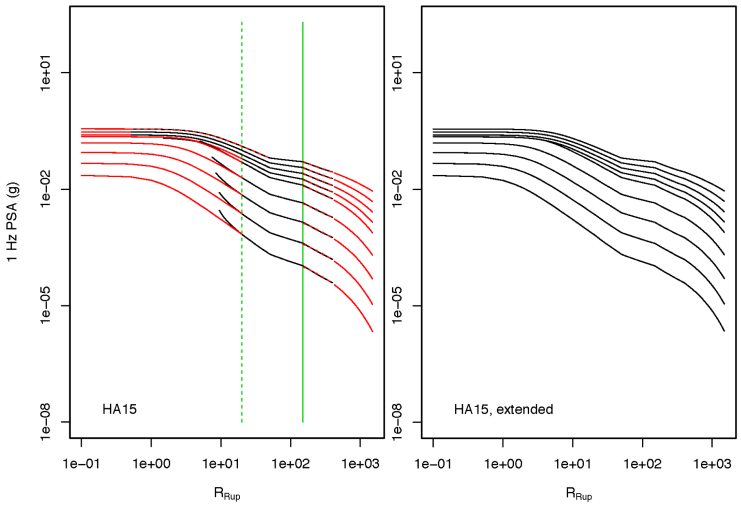
  - Select form that best matched predictions

HA15

- Large distances used standard form with C_2 fixed to -0.5
- Short distances
  - Fit M ≥ 6.9 using form 2, imposing $PSA(M_{i-1}, R) \leq PSA(M_i, R)$ starting with largest magnitude
  - Use fit to M 6.9 to define h, scale h as as function of magnitude to fit smaller magnitudes, removing upward curvature

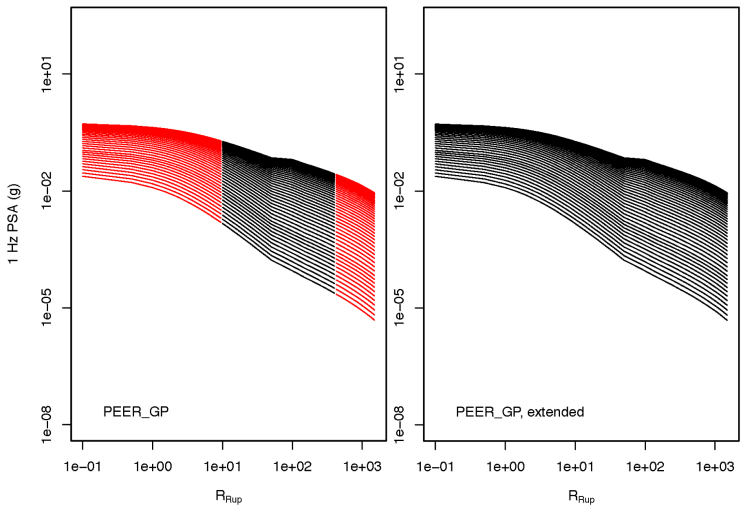
HA15 Example



PEER Models

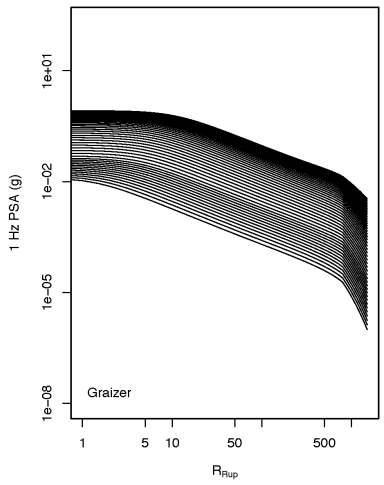
- Large distances
  - Discard data > 400 km
  - Used standard form fit to data up to 400 km
- Short distances
  - Discard data less than 10 km
  - Fit using form 2 to data from 10 to 50 km
  - Allow small degree of oversaturation at higher frequencies

PEER Example



Graizer

- No extensions needed



Issue

- At very large distances unphysical response spectral shapes are produced in some cases
  - Sag in response spectra at high frequencies such that PSA < PGA
  - Results from extrapolation for each magnitude and frequency independently
  - Need to go back and adjust high frequency values to produce realistic spectral shapes