Kappa, Conversion from Hard-Rock to 760 m/s

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Kappa Scaling Approaches

- Will show an examples of approaches
  - Does not directly address the hard-rock -> 760 m/s kappa question
- Acknowledgments
  - Work by Linda Al-Atik, Albert Kotte, Justin Hollenback
  - Funding by Swissnuclear & PG&E

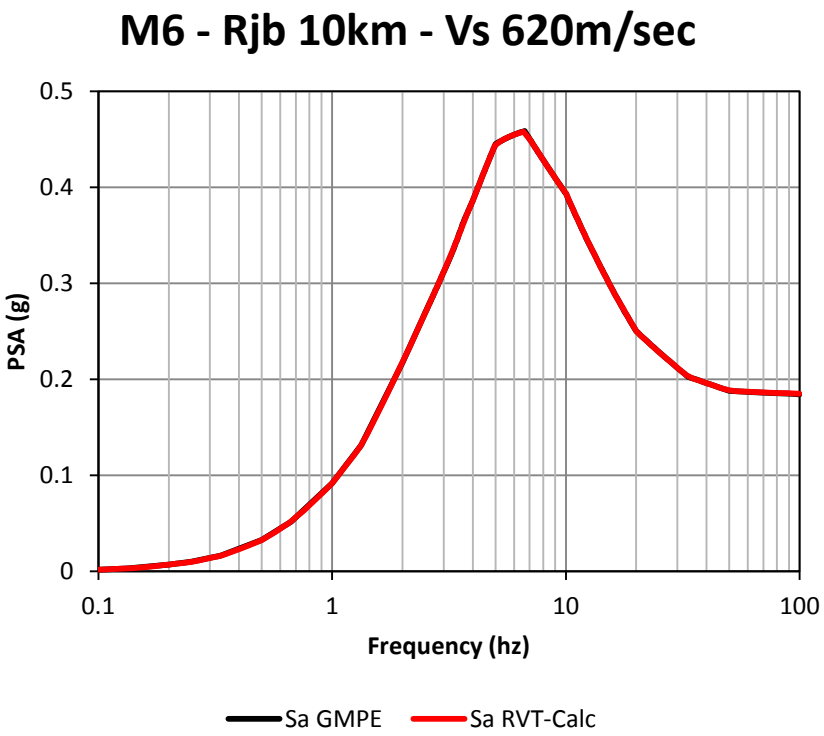
Kappa Scaling Approaches

- IRVT
  - Different Sa scale factors for each GMPE
  - Use IRVT to convert Sa to FAS (for a given GMPE)
  - Apply kappa (and Vs) scaling to FAS
  - Use RVT to convert back to Sa
  - Compute Sa scale factors for the GMPE
  - Reference:
    - Al-Atik et al (2012). Kappa scaling of GMPEs using IRVT, submitted to BSSA, being revised to address review comments, resubmit in Jan 2013
- Empirical
  - Dependence of residual using kappa proxy
  - Reference:
    - Swissnuclear report

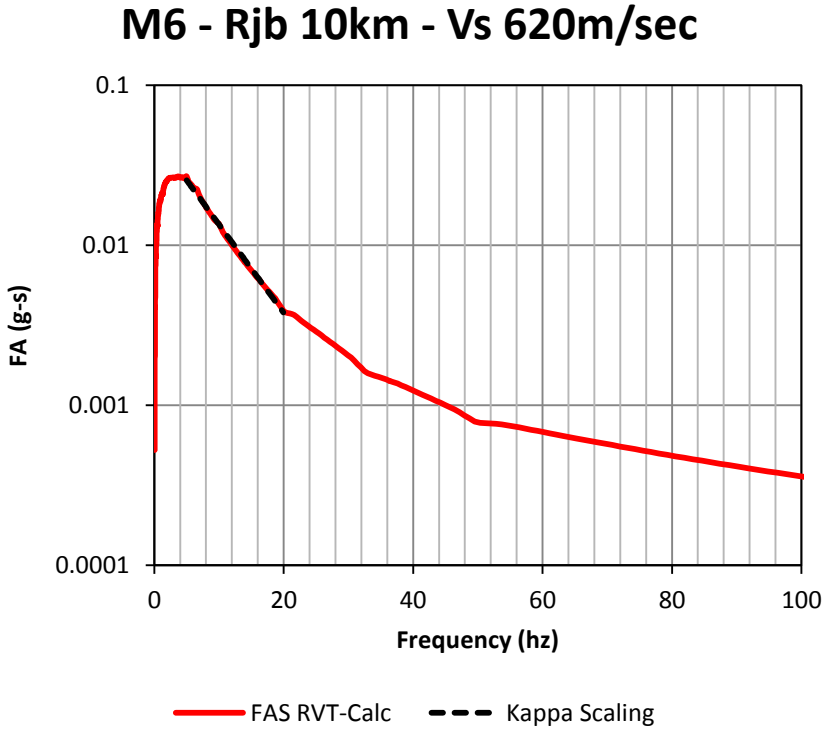
Application Using IRVT Approach

- Host GMPE:
  - **Campbell & Bozorgnia (2008), CB08**
    - WUS generic rock profile with Vs30 of 620 m/sec
    - Average host kappa based on the high frequency slope of IRVT-based FAS
- Target region: **Switzerland**
    - Generic Swiss rock conditions with Vs30 of 1000 m/sec
    - Average target kappa based on the high frequency slope of IRVT-based FAS ($kappa_0$ = 0.017)

Vs-Kappa Scaling of CB08



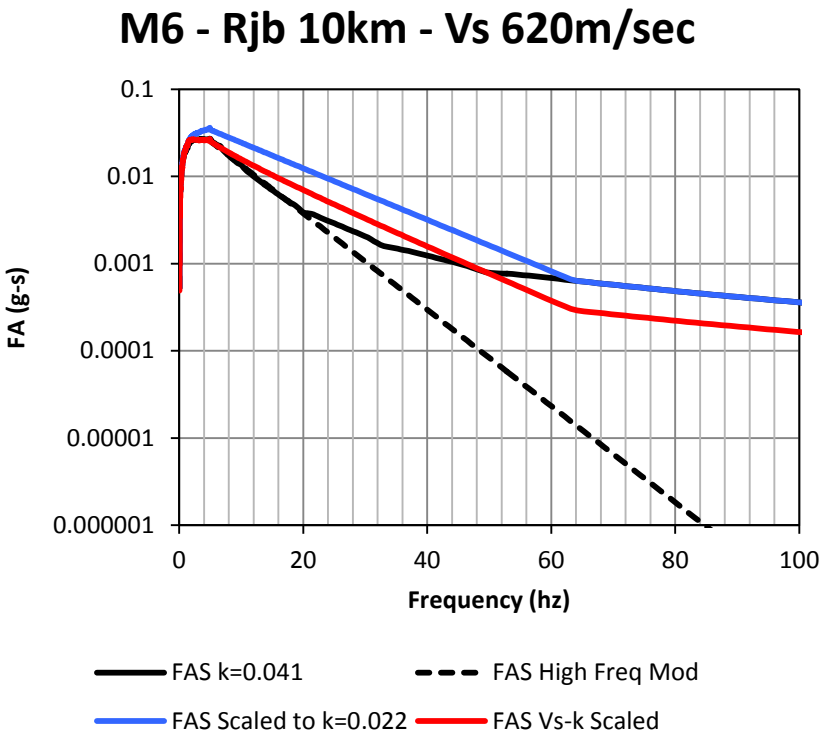
IRVT



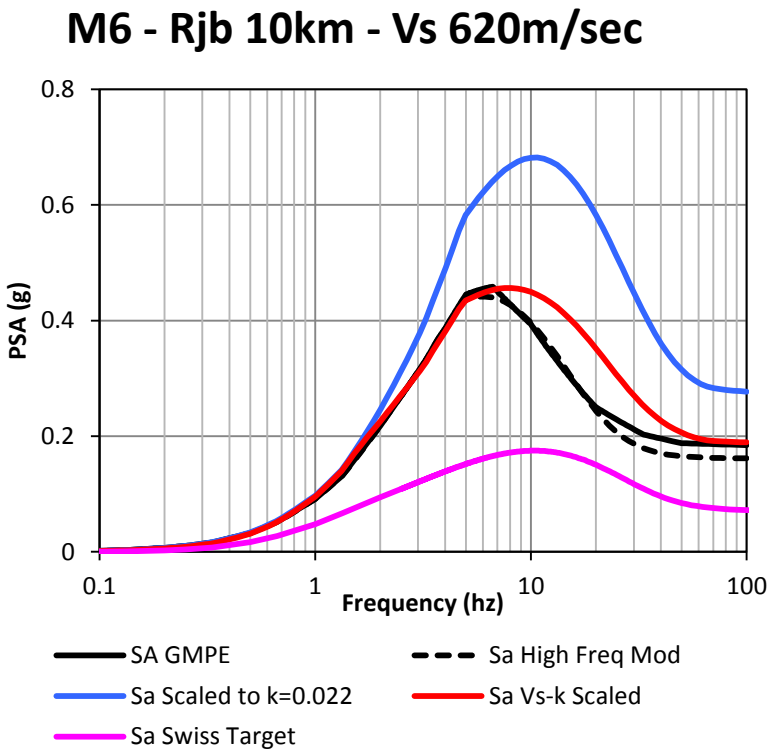
Average host kappa = 0.041 sec, stdev = 0.0015

Average target kappa = 0.022 sec ($kappa_0$ = 0.017), stdev = 0.0019

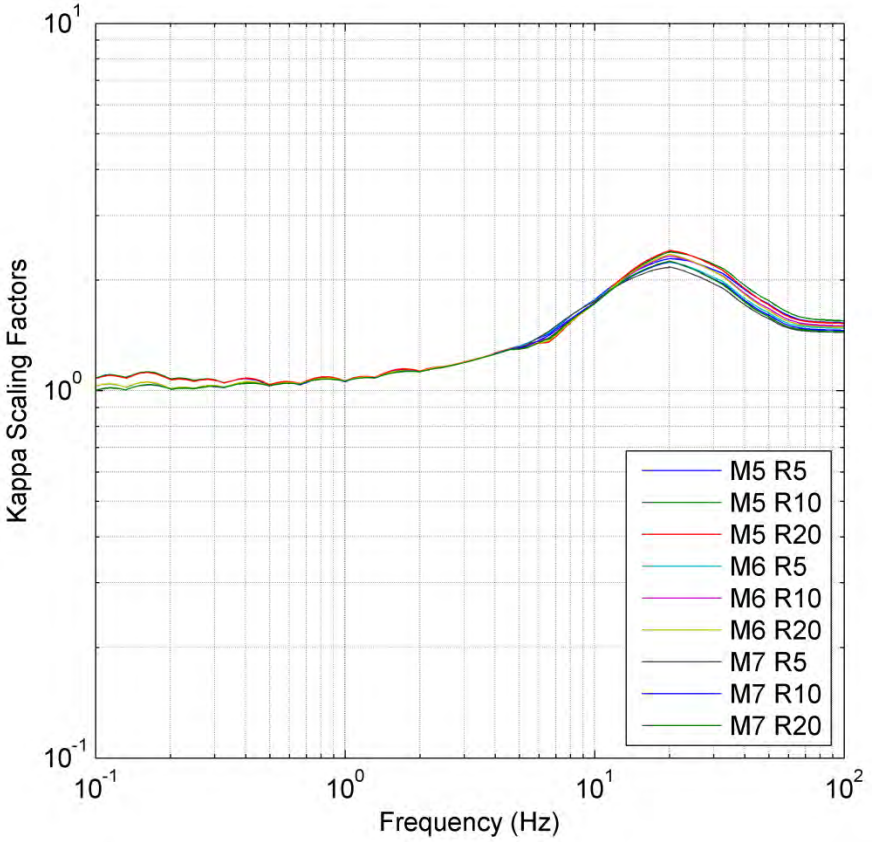
Vs-Kappa Scaling of CB08 (cont'd)

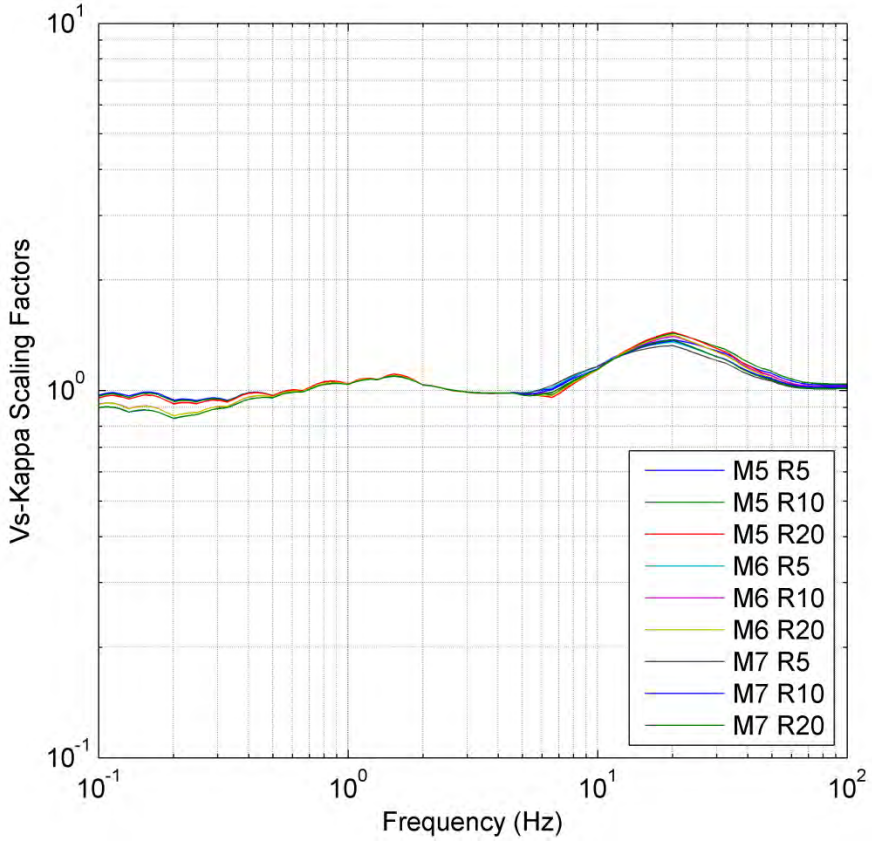


RVT

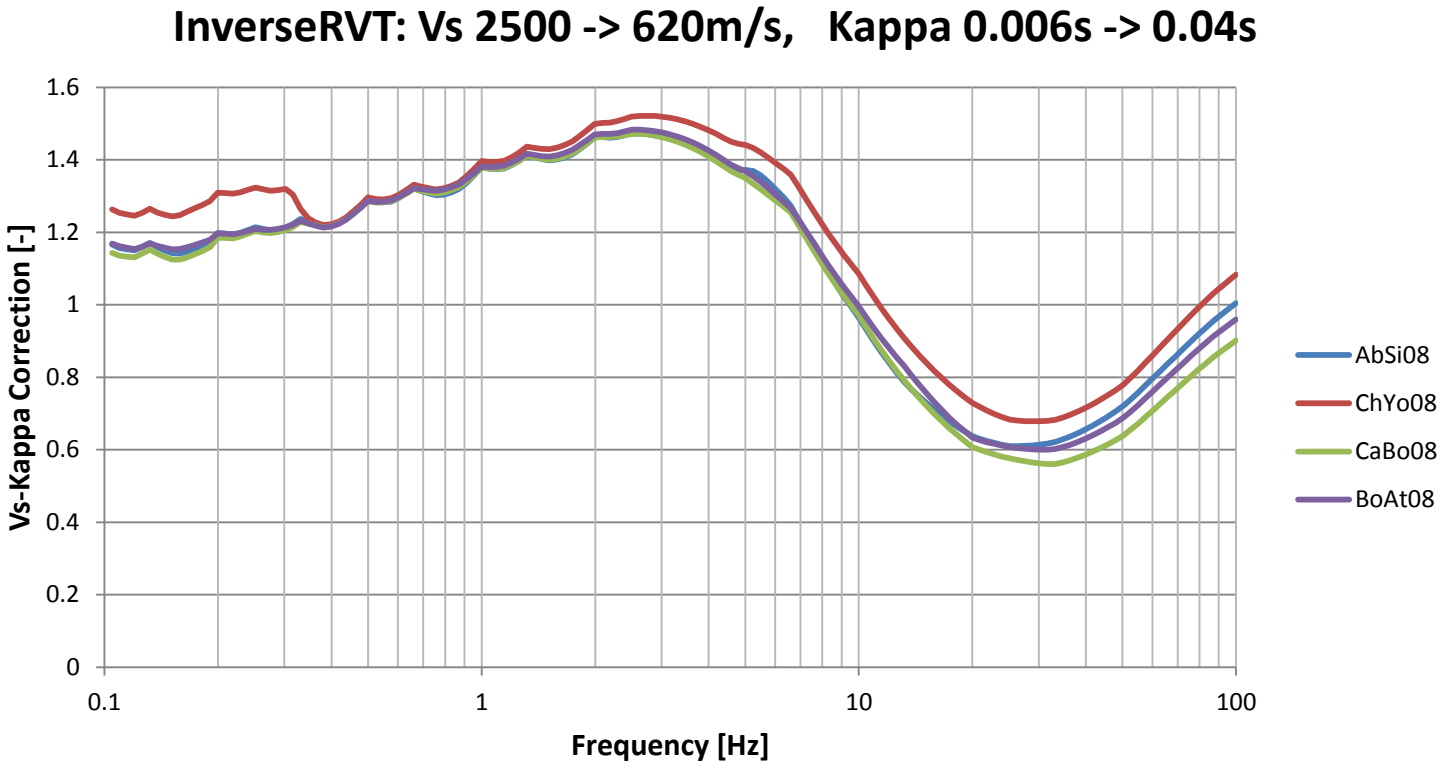


Scaling Factors for CB08



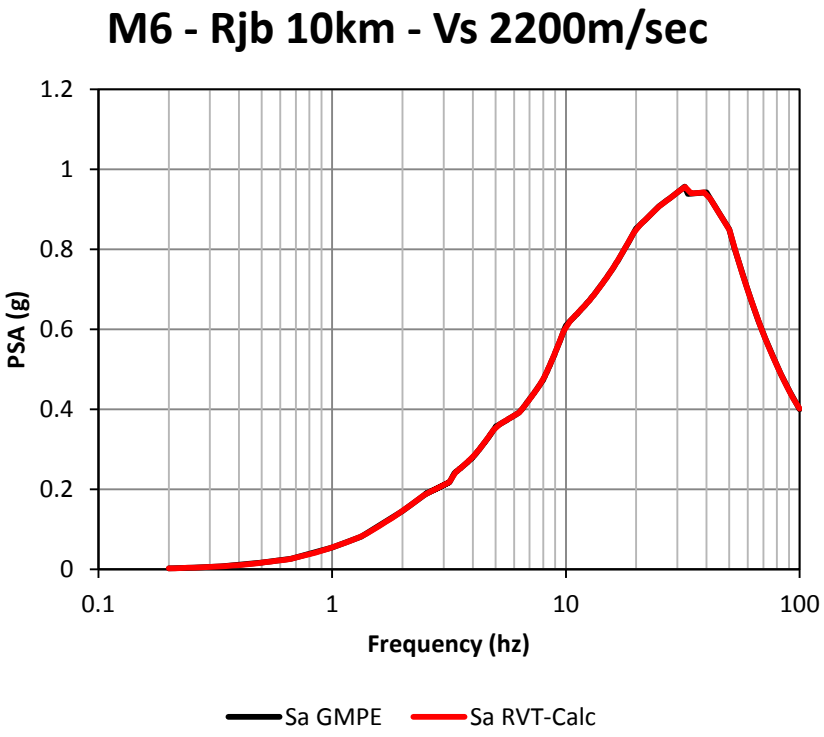


Example
(inverse of scale factor from WUS-CUES)

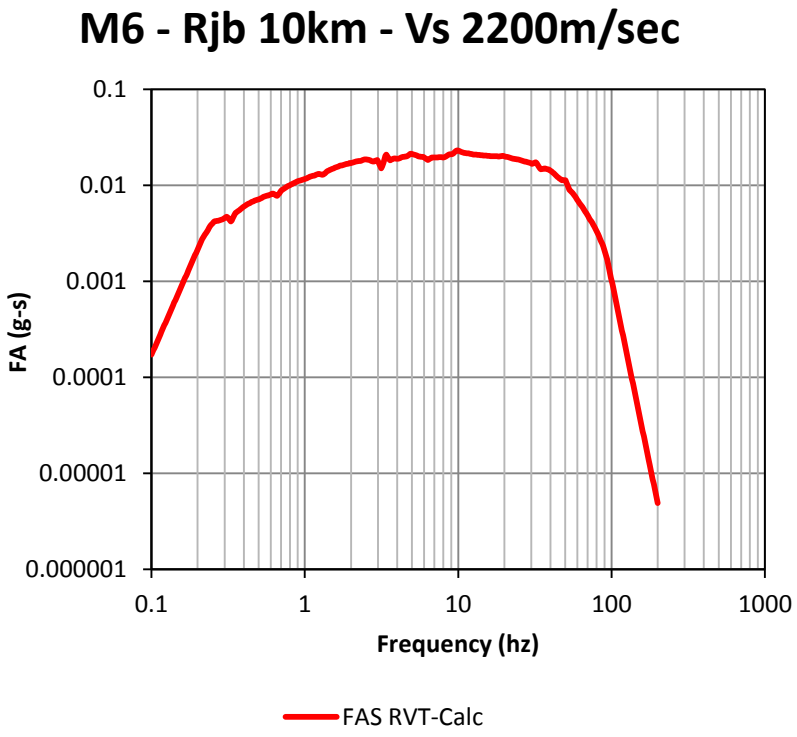


from: Philippe Renault, swissnuclear

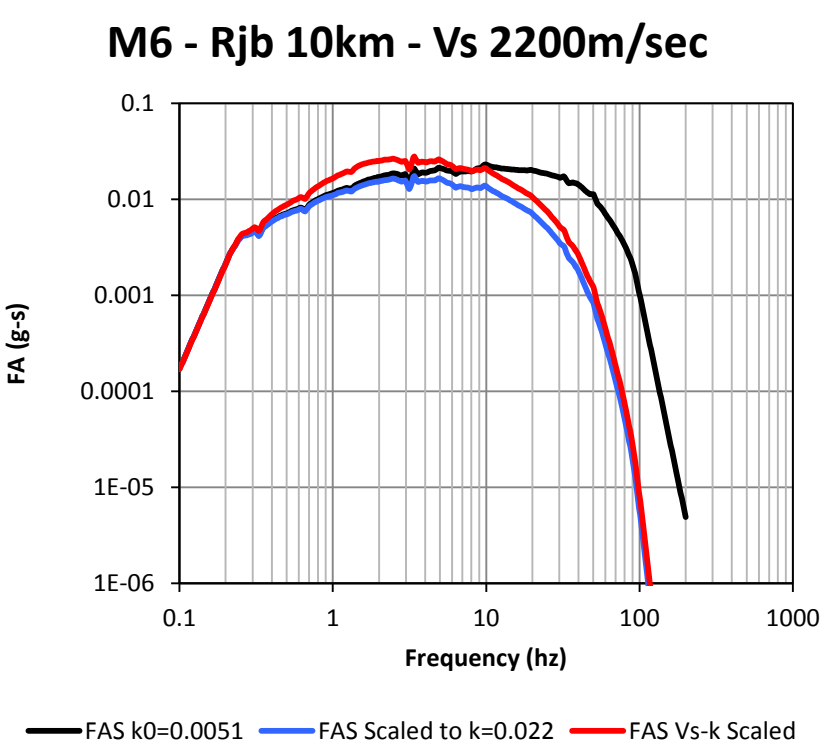
Vs-Kappa Scaling of AtBo06



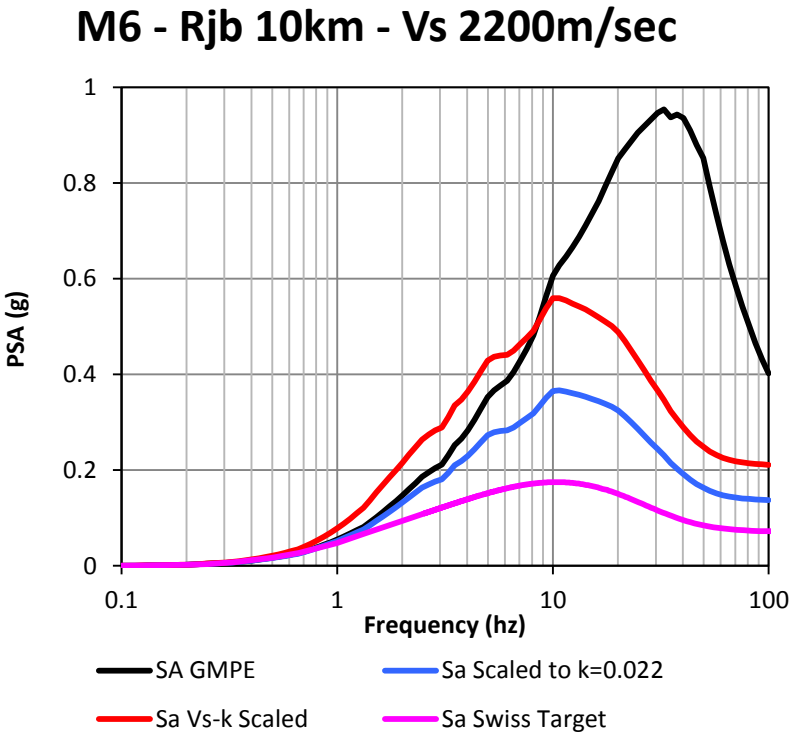
IRVT



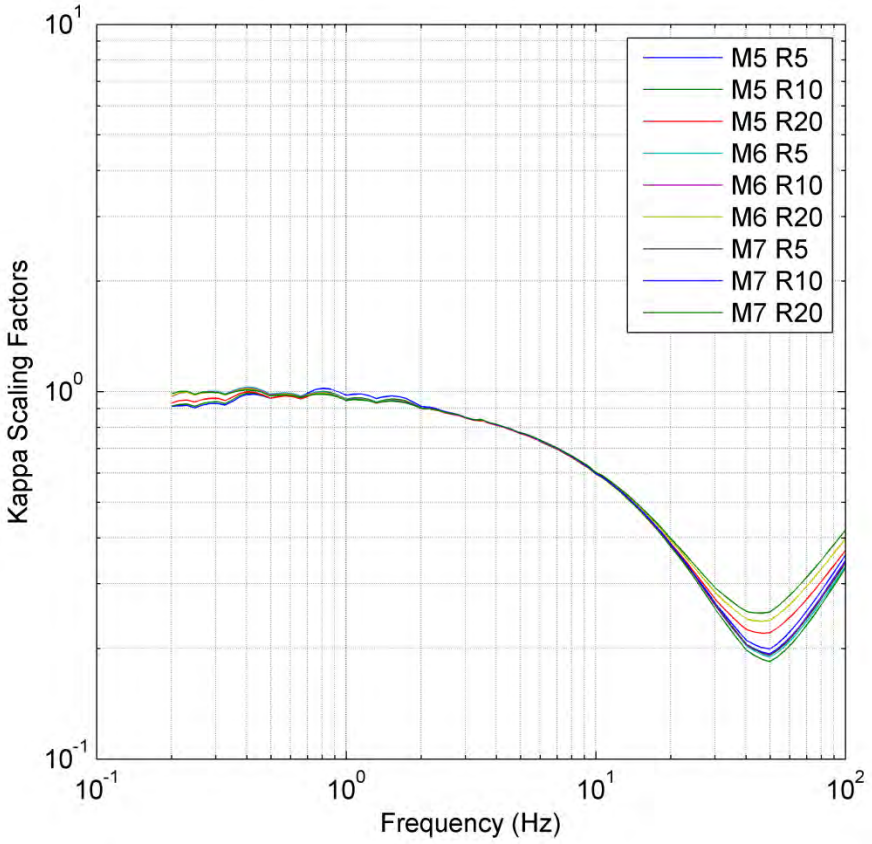
Vs-Kappa Scaling of AtBo06 (cont'd)

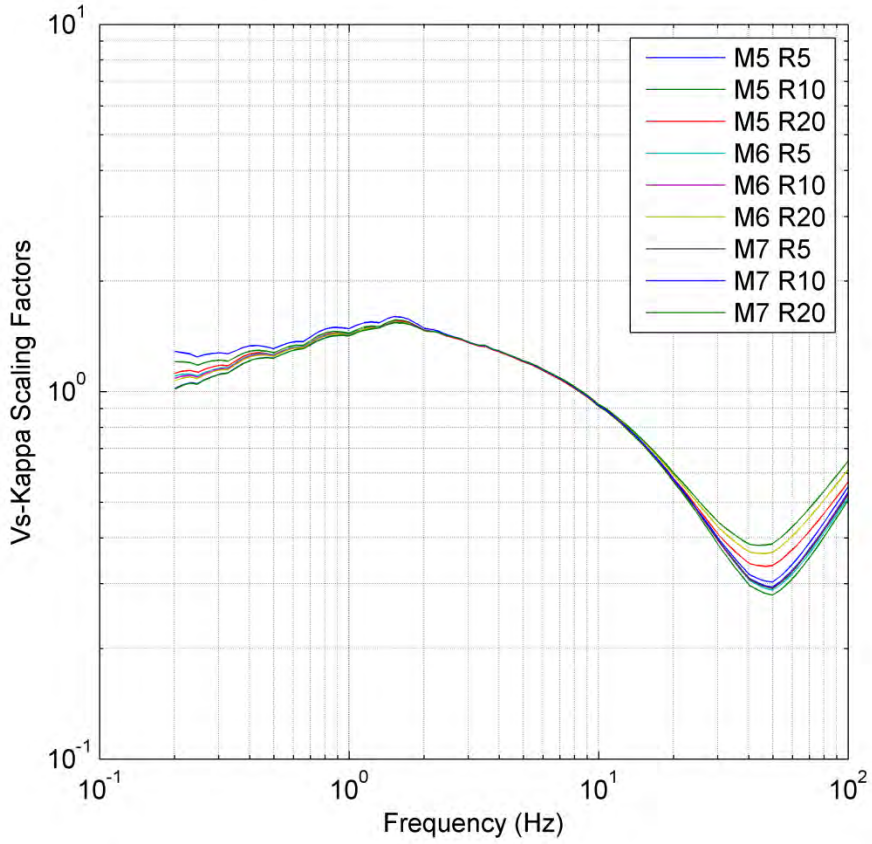


RVT



Scaling Factors for AtBo06





Potential Strengths of IRVT Approach

- Simple and transparent
- Applies scaling in Fourier domain as opposed to response spectra domain
- Does not require a full seismological model for stochastic parameters of host and target regions
- Does not assume that response spectral shape of GMPE is consistent with that of the point source stochastic model

Potential Weaknesses of IRVT Approach

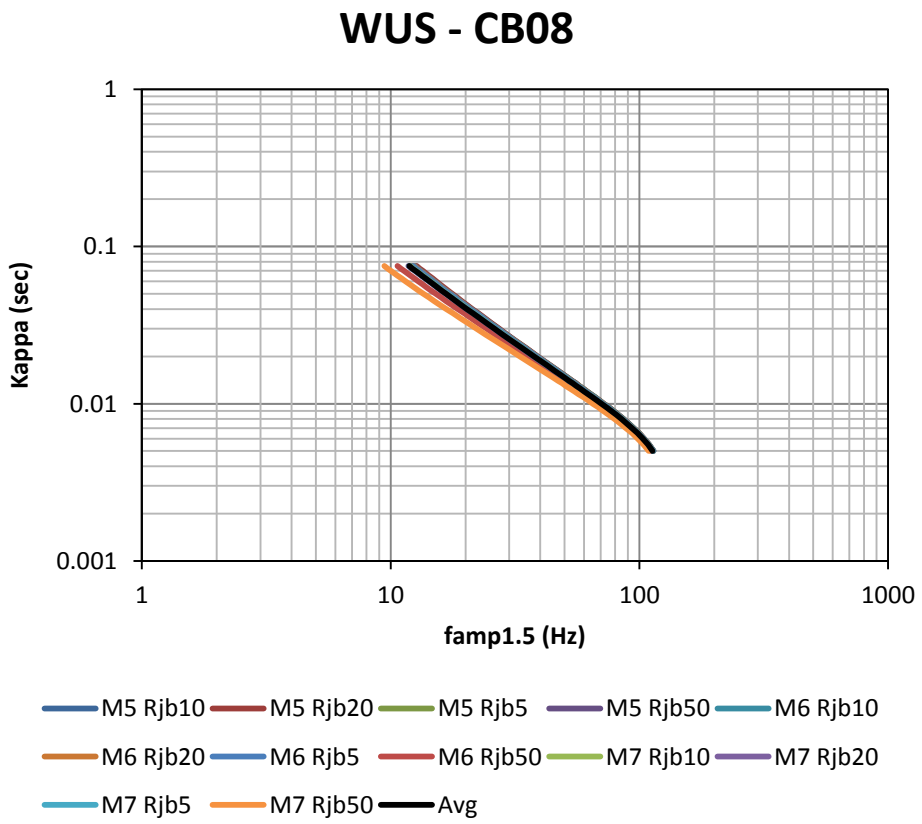
- Relies on IRVT to produce response spectra-compatible FAS
  - Saturation of response spectra with large kappa limits the ability to characterize high frequency content of ground motion
- Requires that Anderson & Hough (1984) kappa scaling fits reasonably well the high frequency FAS

Empirical Approach

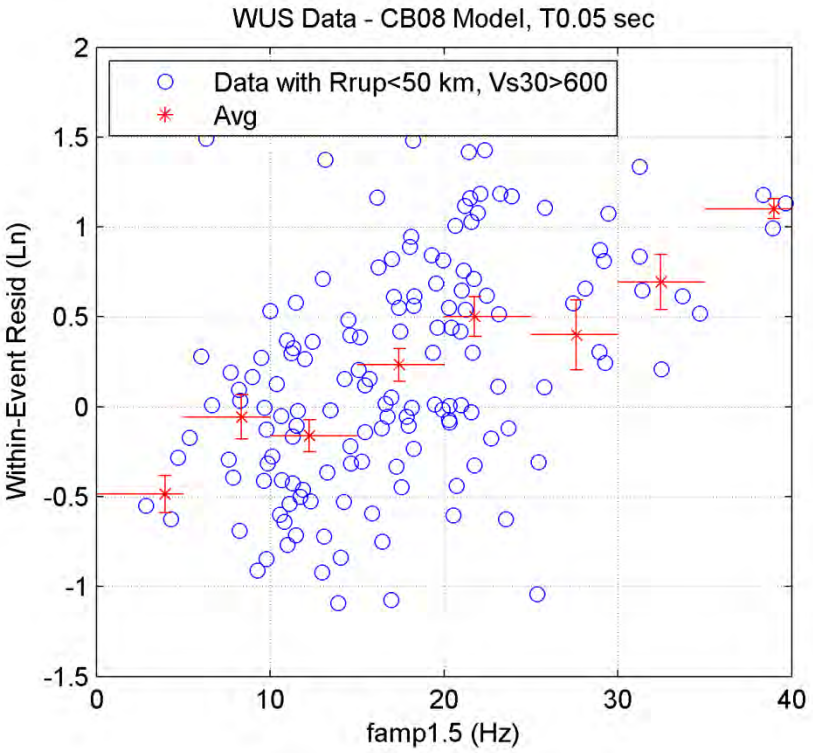
- Ideal approach
  - kappa estimates for each station in the data set
  - Evaluate within-event residuals dependence on kappa
- Proxy approach
  - Use the highest frequency at which the Sa is 1.5 times the PGA as a procxy for kappa
  - Develop conversion from the proxy to kappa based on the point source stochastic model
  - Evaluate within-event residuals dependence on kappa

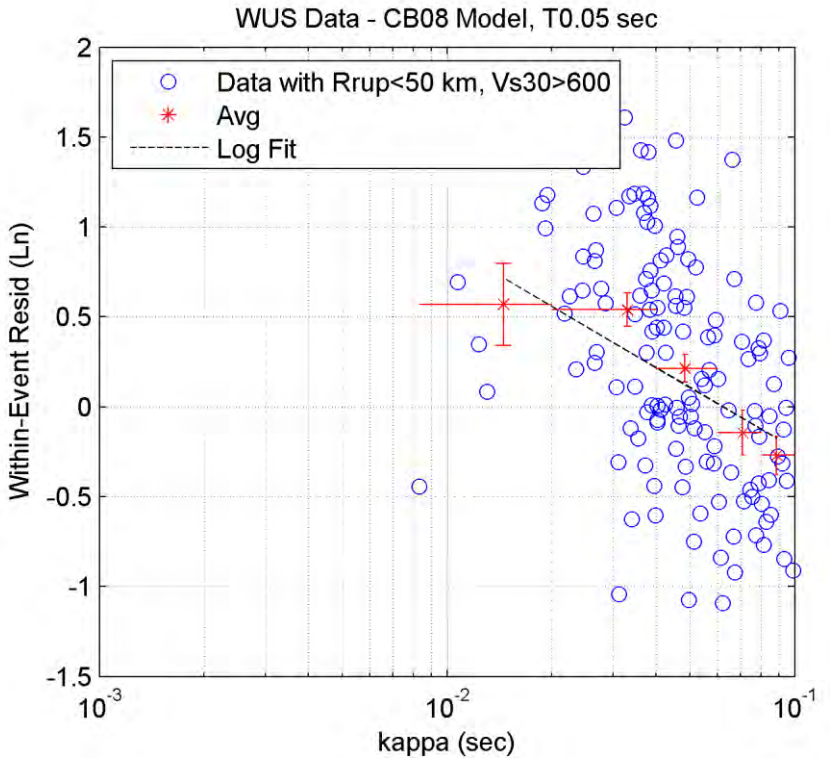
Kappa Estimates

Kappa-famp1.5 relationships developed from kappa-scaled GMPE response spectra using IRVT approach for a range of M-R scenarios



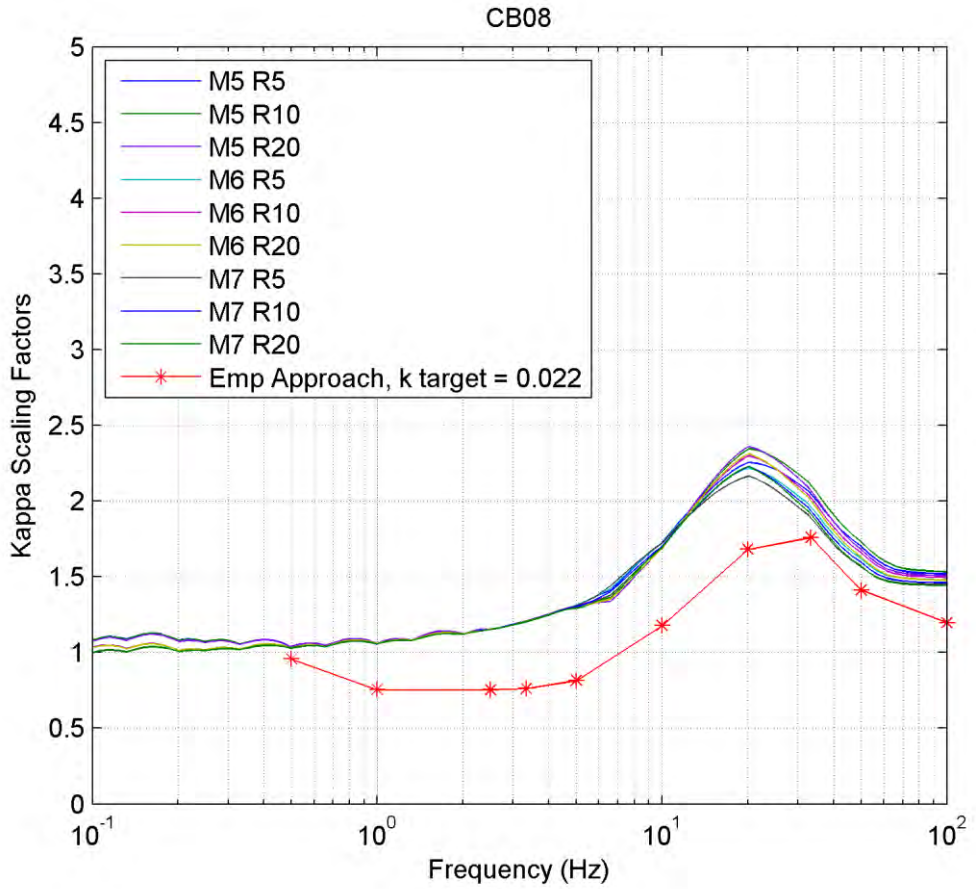
Vs-Kappa Scaling of WUS Data – CB08





$$k\ Scaling\ Factor\ (T\ 0.05\ sec) = Exp(-0.492Ln(k) - 1.368)$$

Kappa Scaling Functions: WUS to Generic Swiss Rock Conditions



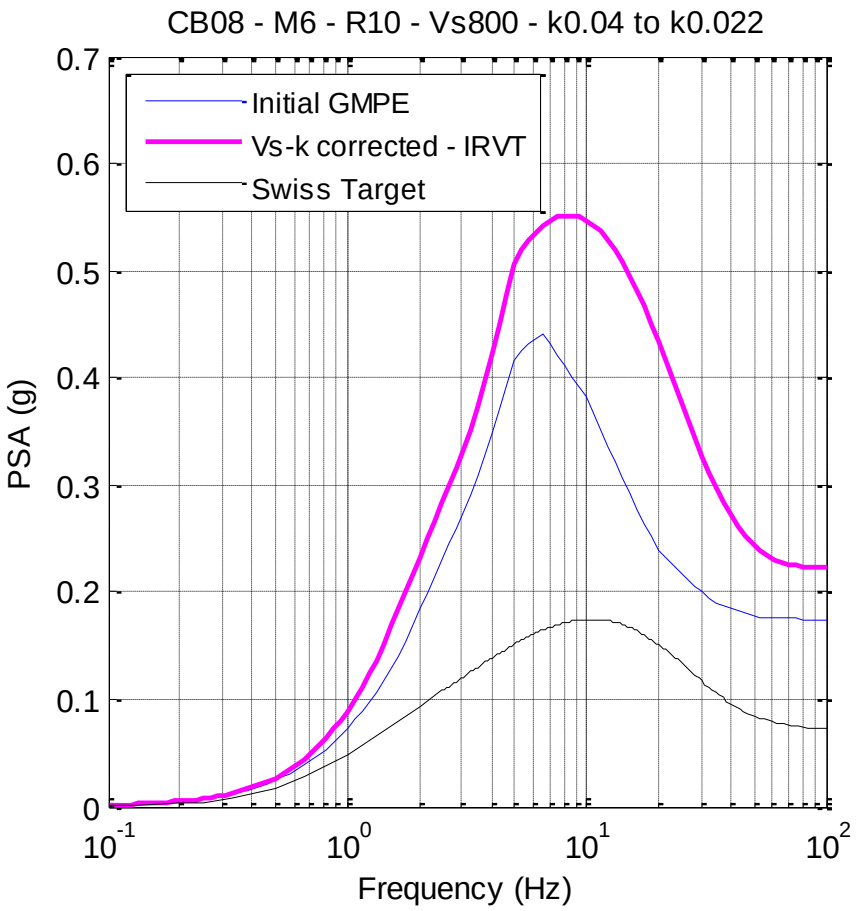
Potential Strengths of Empirical Approach

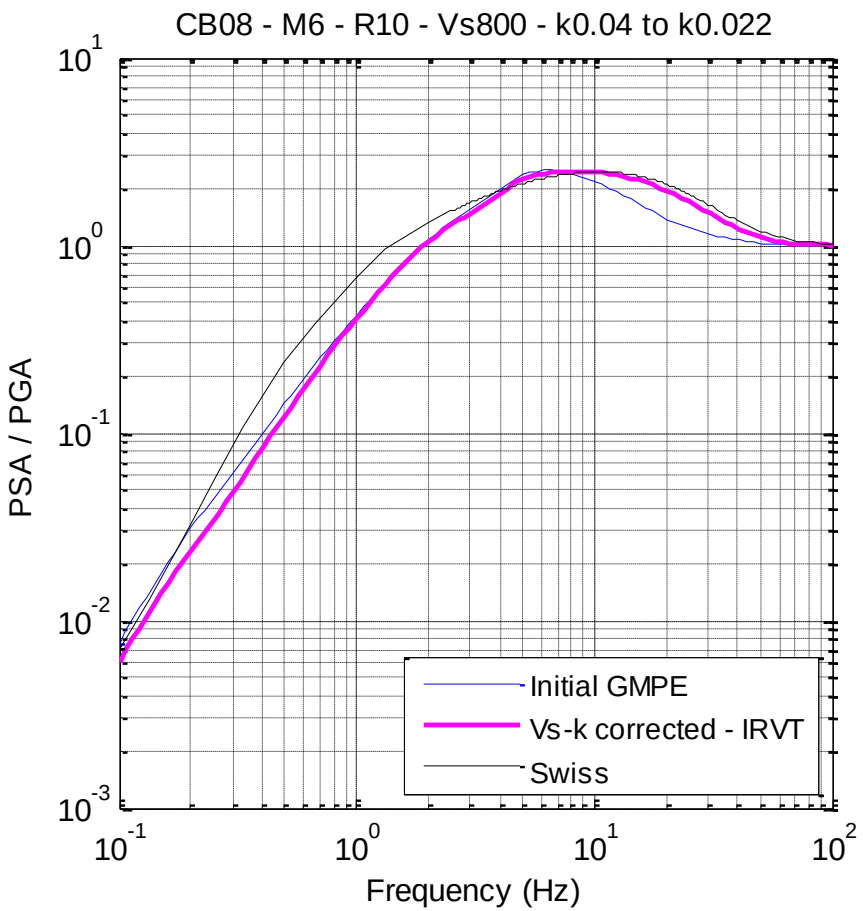
- Relies on empirical ground motion data to evaluate Vs-kappa scaling
- Does not require seismological properties of host and target regions asides from target kappa value
- Simple and can be easily applied to evaluate scaling factors for a range of target kappa values

Potential Weaknesses of Empirical Approach

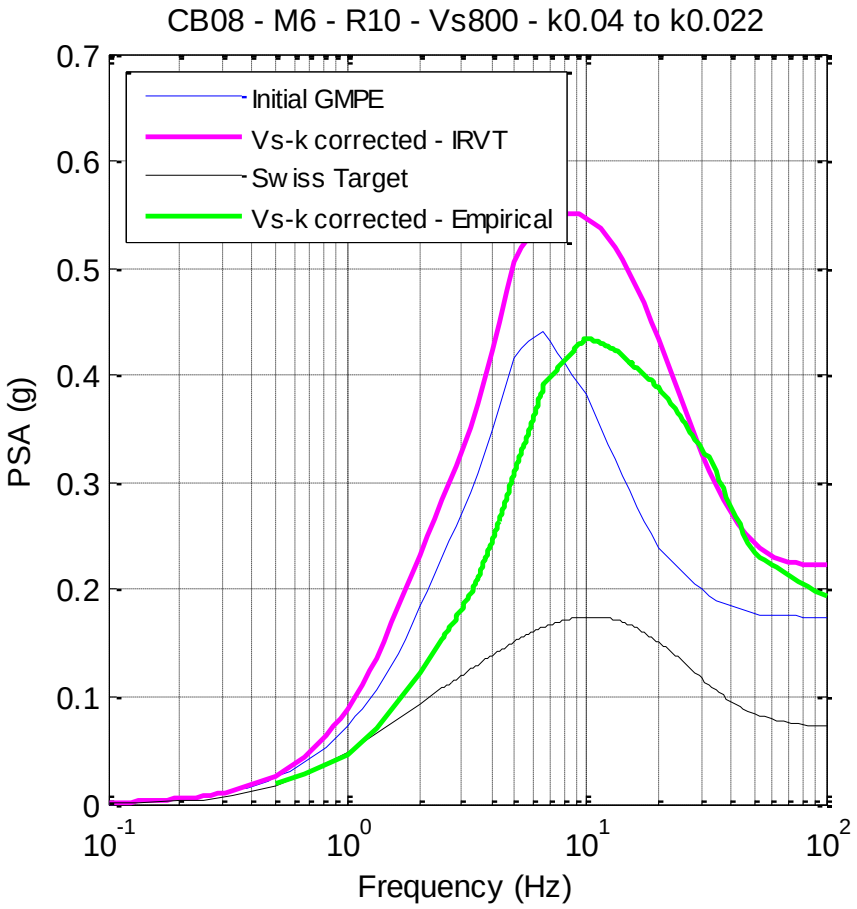
- Few recordings available at short distance on stiff soil and rock sites to constrain kappa scaling
- Relies on kappa proxy
  - Different kappa values for a single station with multiple recordings
- Assumes GMPE scaling for high Vs30 is correct

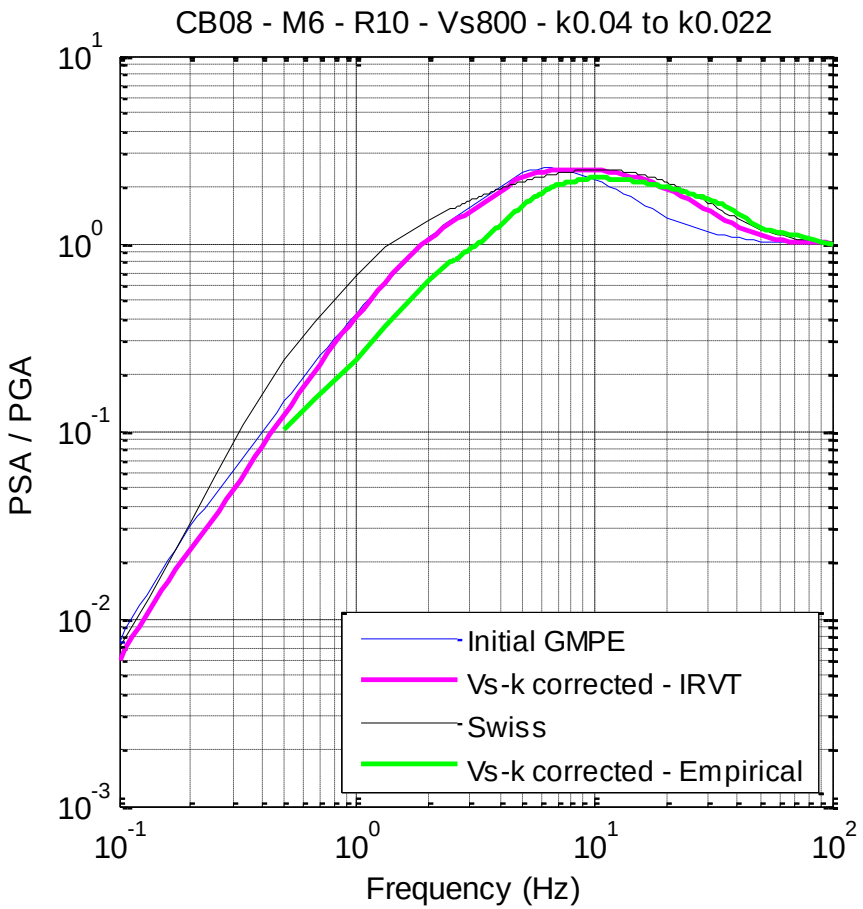
Comparison of CB08 Corrected Spectra

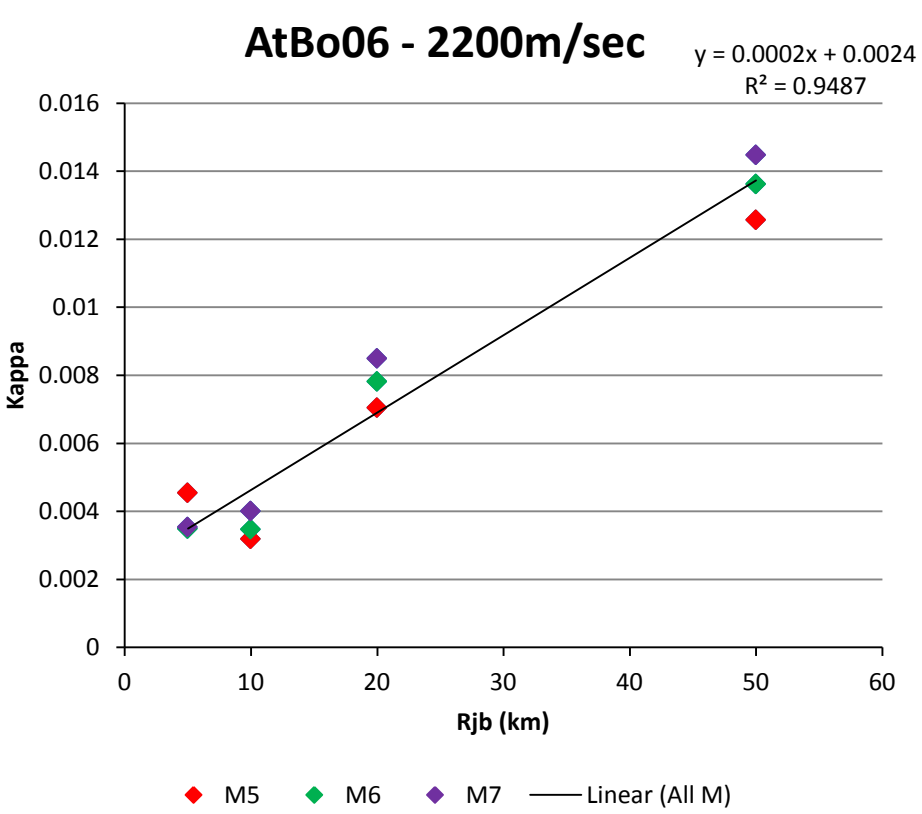


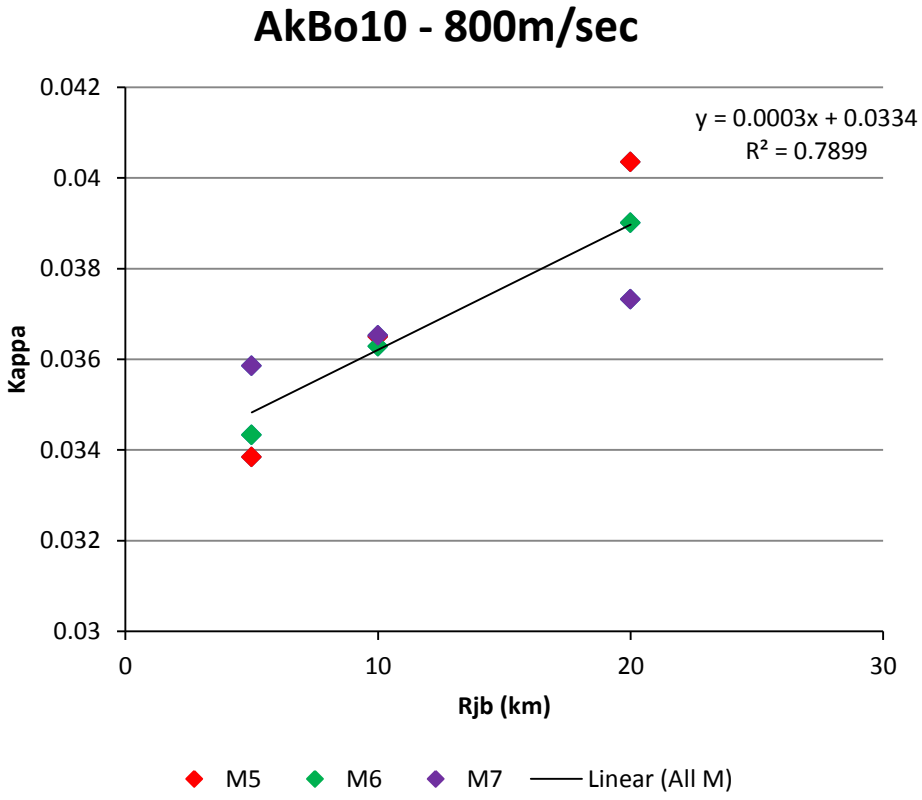


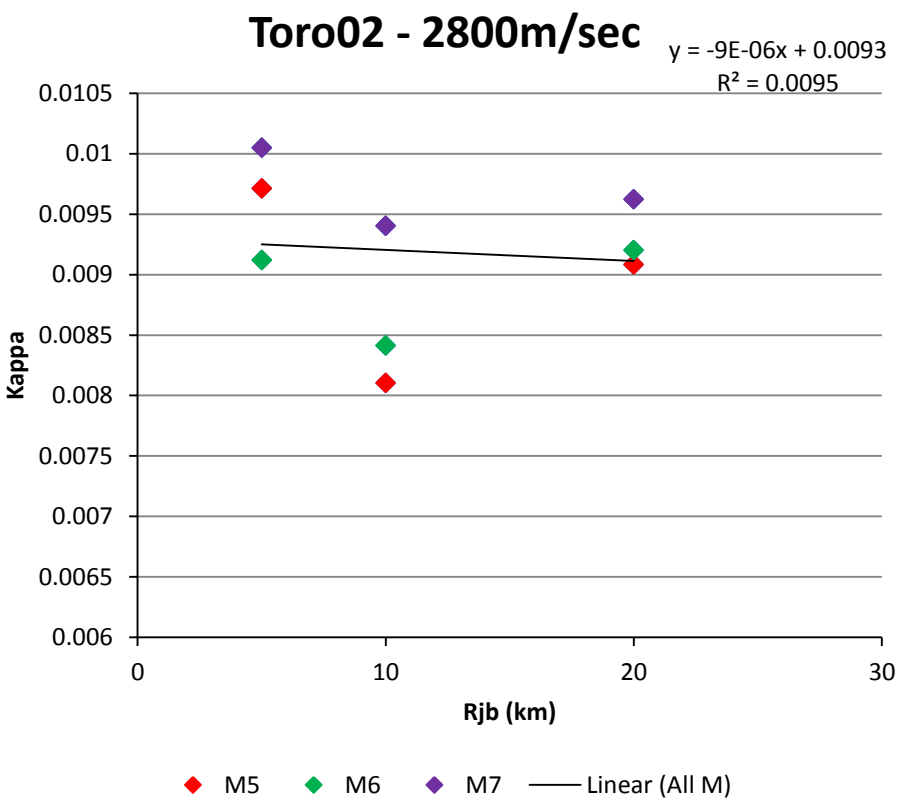
Comparison of CB08 Corrected Spectra

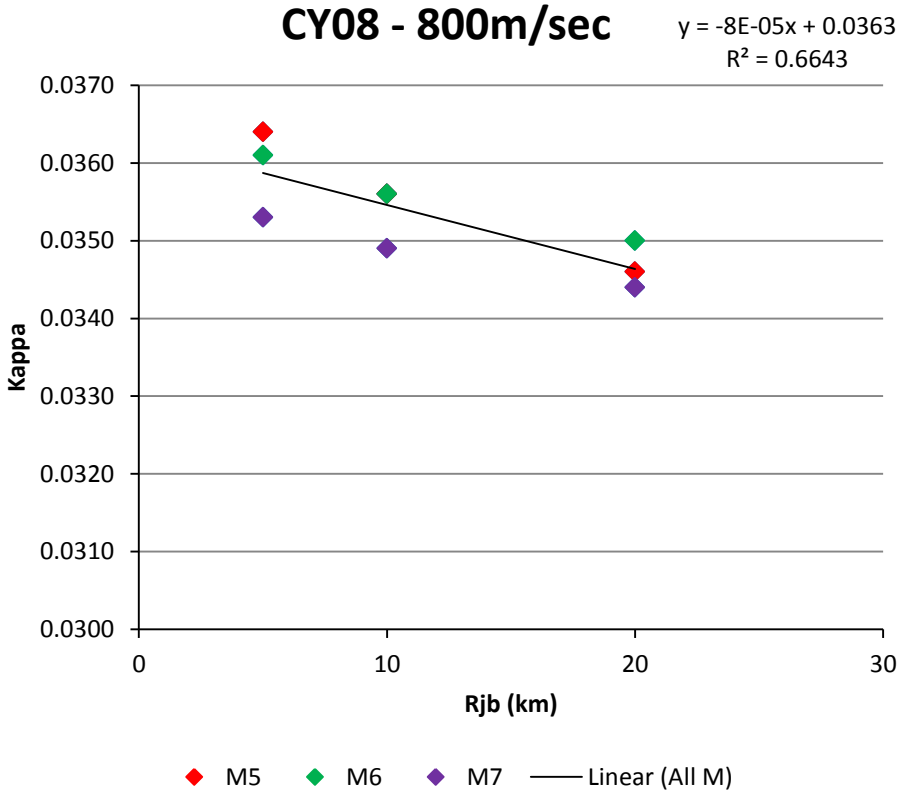





AtBo06 - 2200m/sec
y = 0.0002x + 0.0024
R² = 0.9487
0.016
0.014
0.012
0.01
0.008
0.006
0.004
0.002
0
Kappa
0
10
20
30
40
50
60
Rjb (km)
M5
M6
M7
Linear (All M)


AkBo10 - 800m/sec
y = 0.0003x + 0.0334
R² = 0.7899
0.042
0.04
0.038
0.036
0.034
0.032
0.03
Kappa
0
10
20
30
Rjb (km)
M5
M6
M7
Linear (All M)


Toro02 - 2800m/sec
y = -9E-06x + 0.0093
R² = 0.0095
0.0105
0.01
0.0095
0.009
0.0085
0.008
0.0075
0.007
0.0065
0.006
Kappa
0
10
20
30
Rjb (km)
M5
M6
M7
Linear (All M)


CY08 - 800m/sec
y = -8E-05x + 0.0363
R² = 0.6643
0.0370
0.0360
0.0350
0.0340
0.0330
0.0320
0.0310
0.0300
Kappa
0
10
20
30
Rjb (km)
M5
M6
M7
Linear (All M)