

# Current ENA GMPE Residual Analysis Using the NGA East Ground Motion Database

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A presentation at the USGS CEUS  
Attenuation Workshop in Berkeley CA  
December 12, 2012

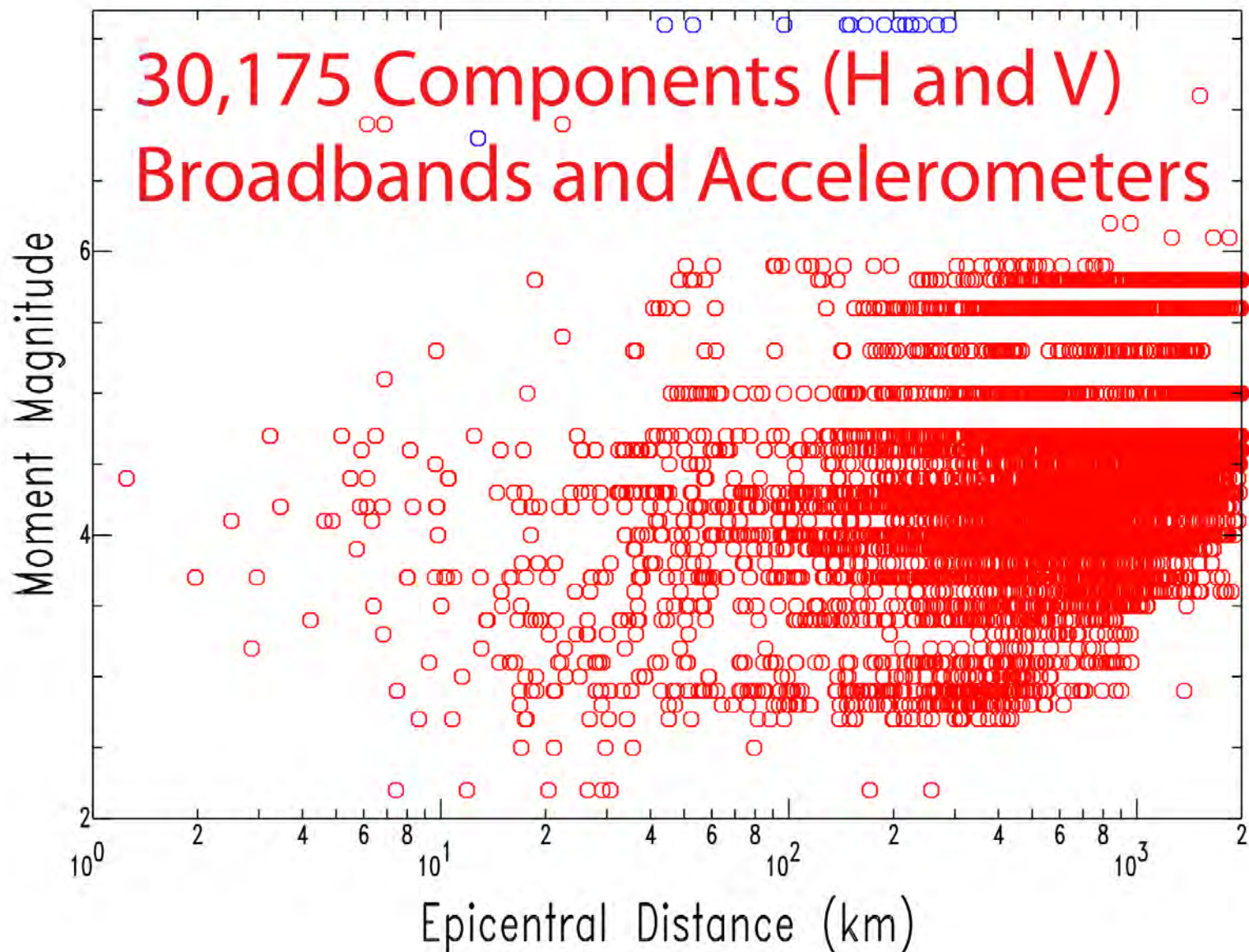
# Overview

- The NGA East Ground Motion Database
- Data Selection for Residual Analysis
- Approach
- Results

# NGA East Ground Motion Database

- 90 Earthquakes, mostly  $M < 6$ , including M7.6 2001 Bhuj India and M6.8 1976 Gazli USSR earthquakes
- 1,466 recording stations
- 11,053 records, 1 to 3 component
- Recording distances from less than 10 to more than 1000 km

# NGA East Ground Motions



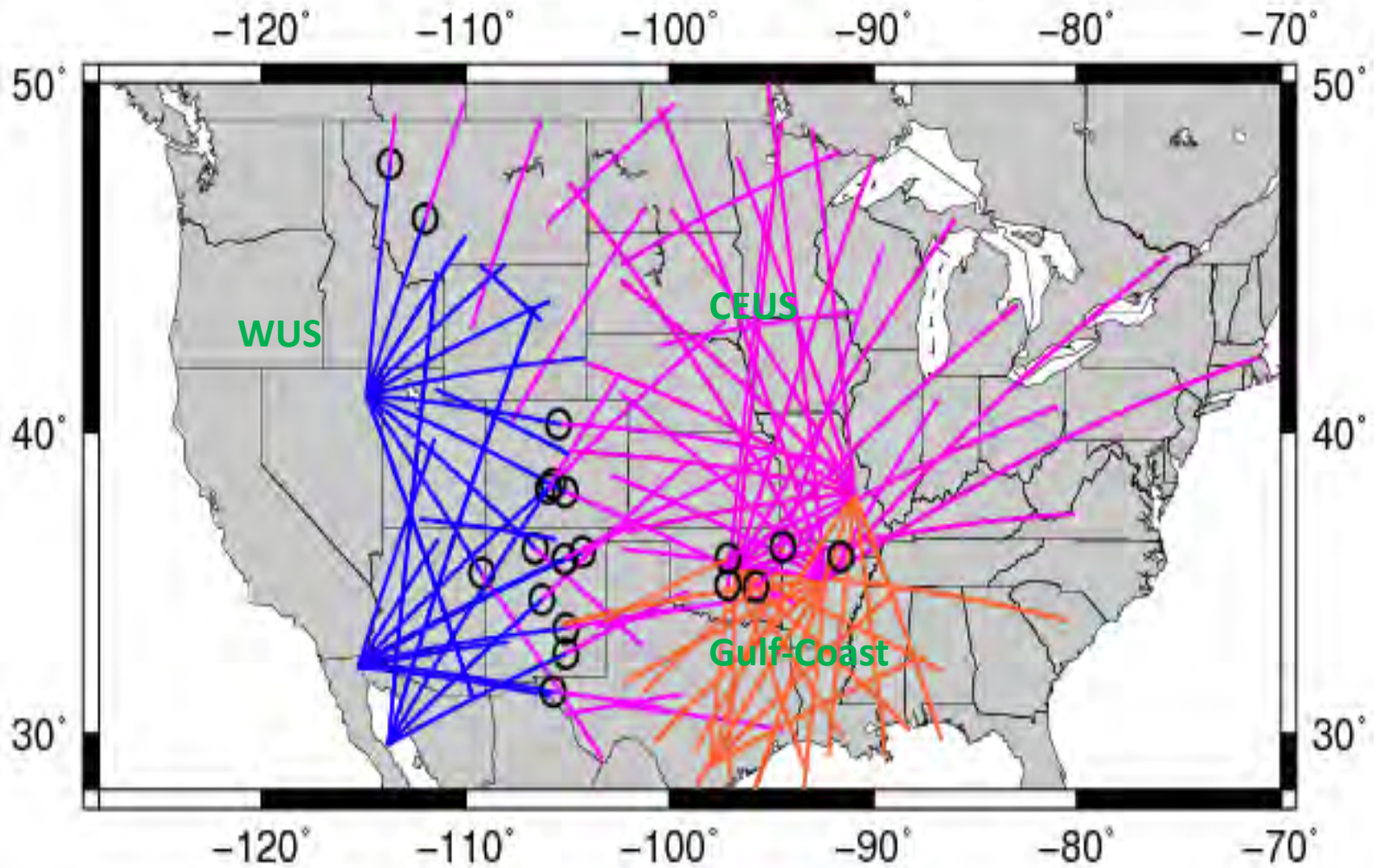
Blue - Bhuj, Gazli

Red - ENA

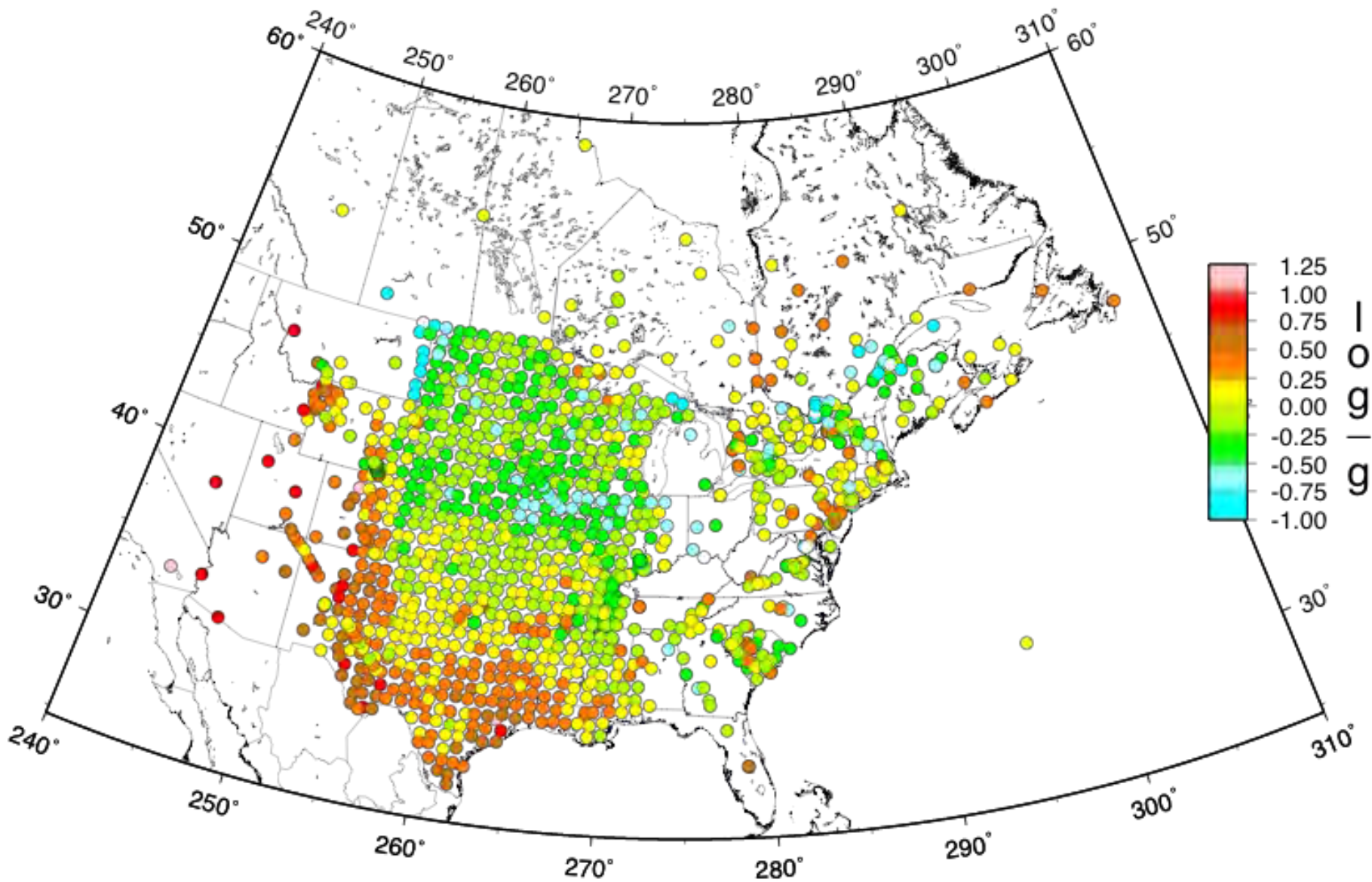
# Data Selection for Residual Analysis

- Avoid higher attenuation in Gulf Coast
- Assigned site classification by soil thickness:
  - Rock is less than 5 m of soil
  - Soil is 5m – 100m of soil
  - Deep Soil greater than 100 m

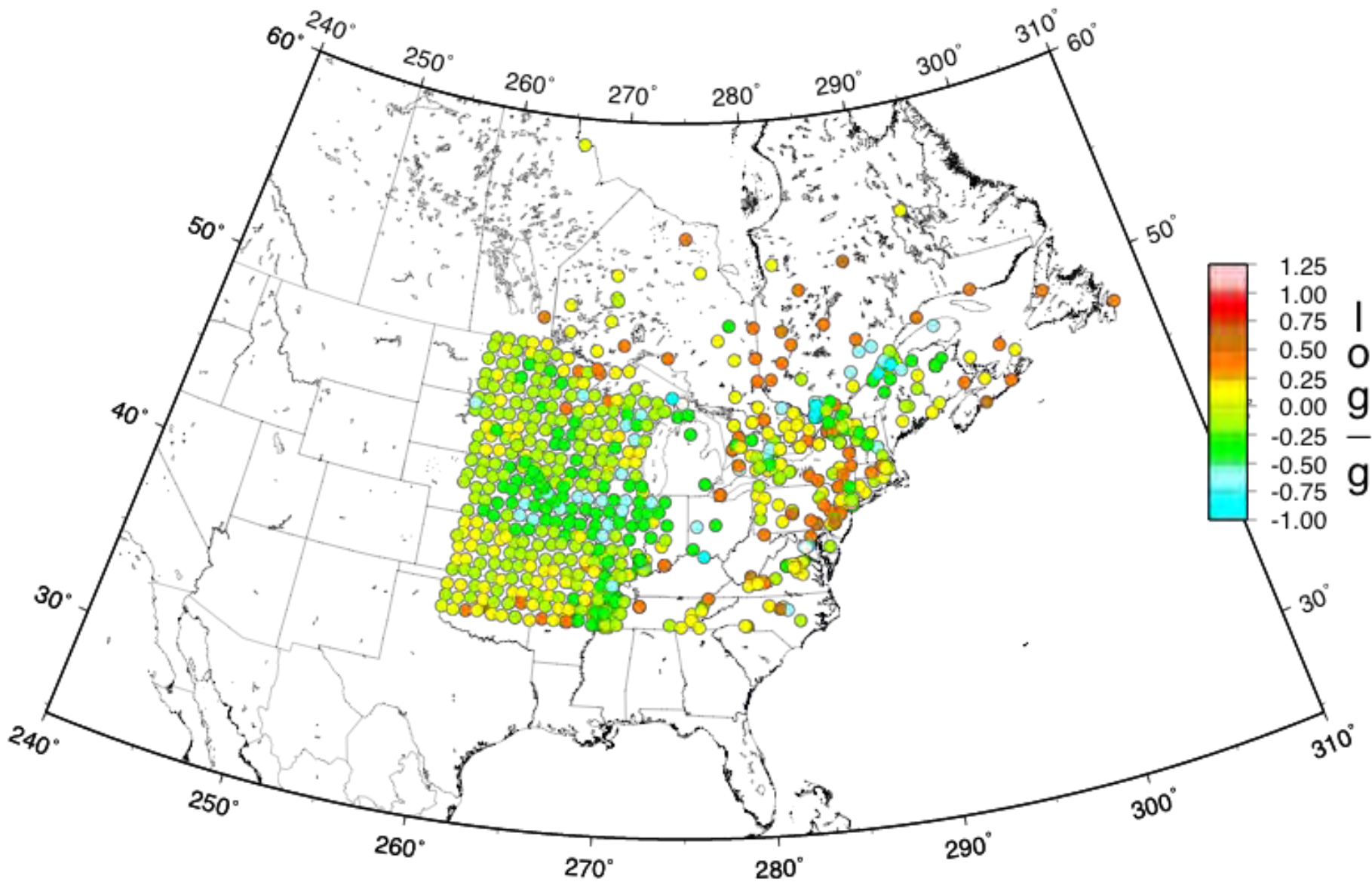
Possible trend of transition region:



# AB06+ Station Mean PGA Residuals

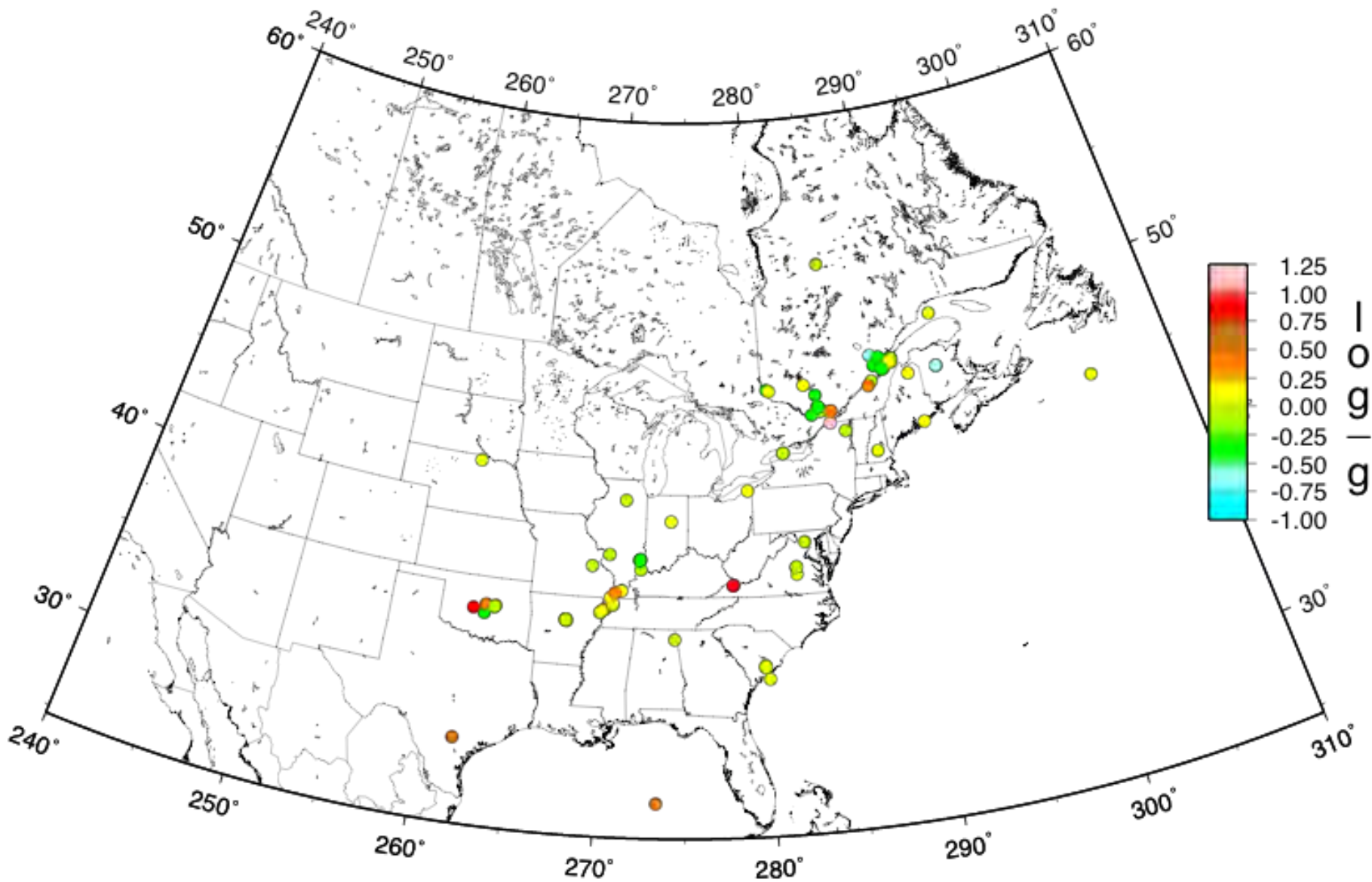


# AB06+ Station Mean PGA Residuals

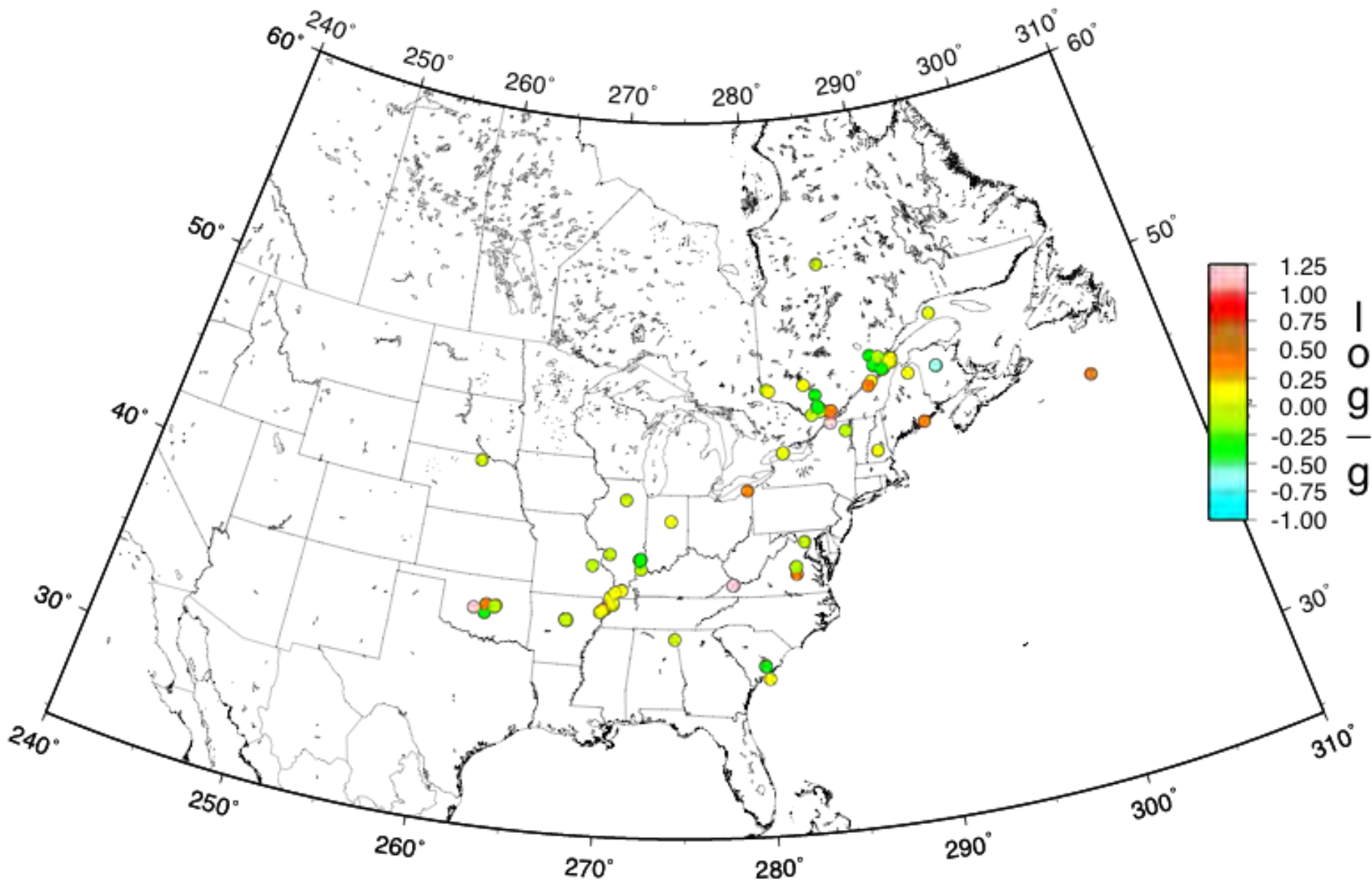




# AB06+ Event Mean PGA Residuals

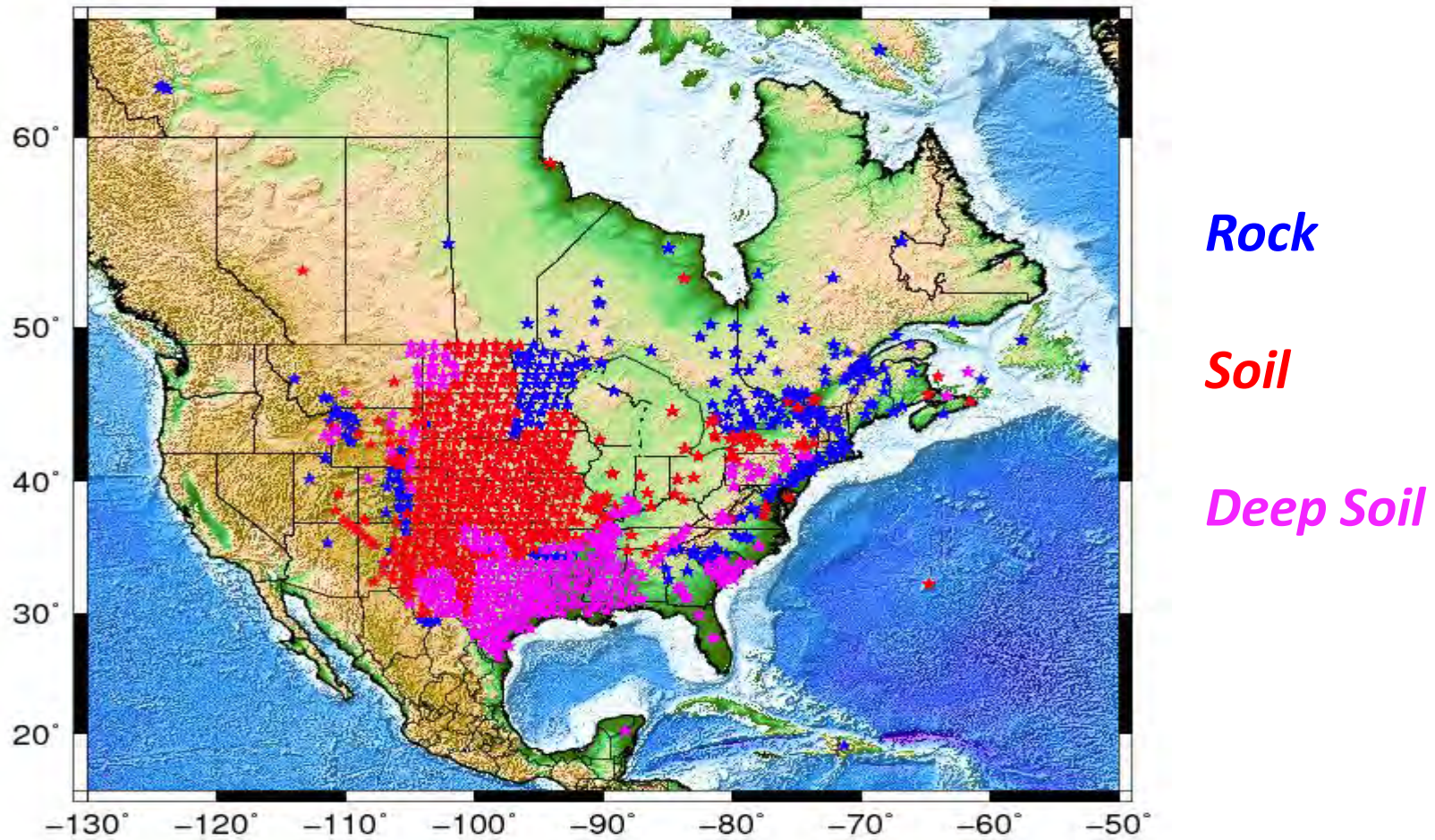


# AB06+ Event Mean PGA Residuals



## Site-Soil Classification

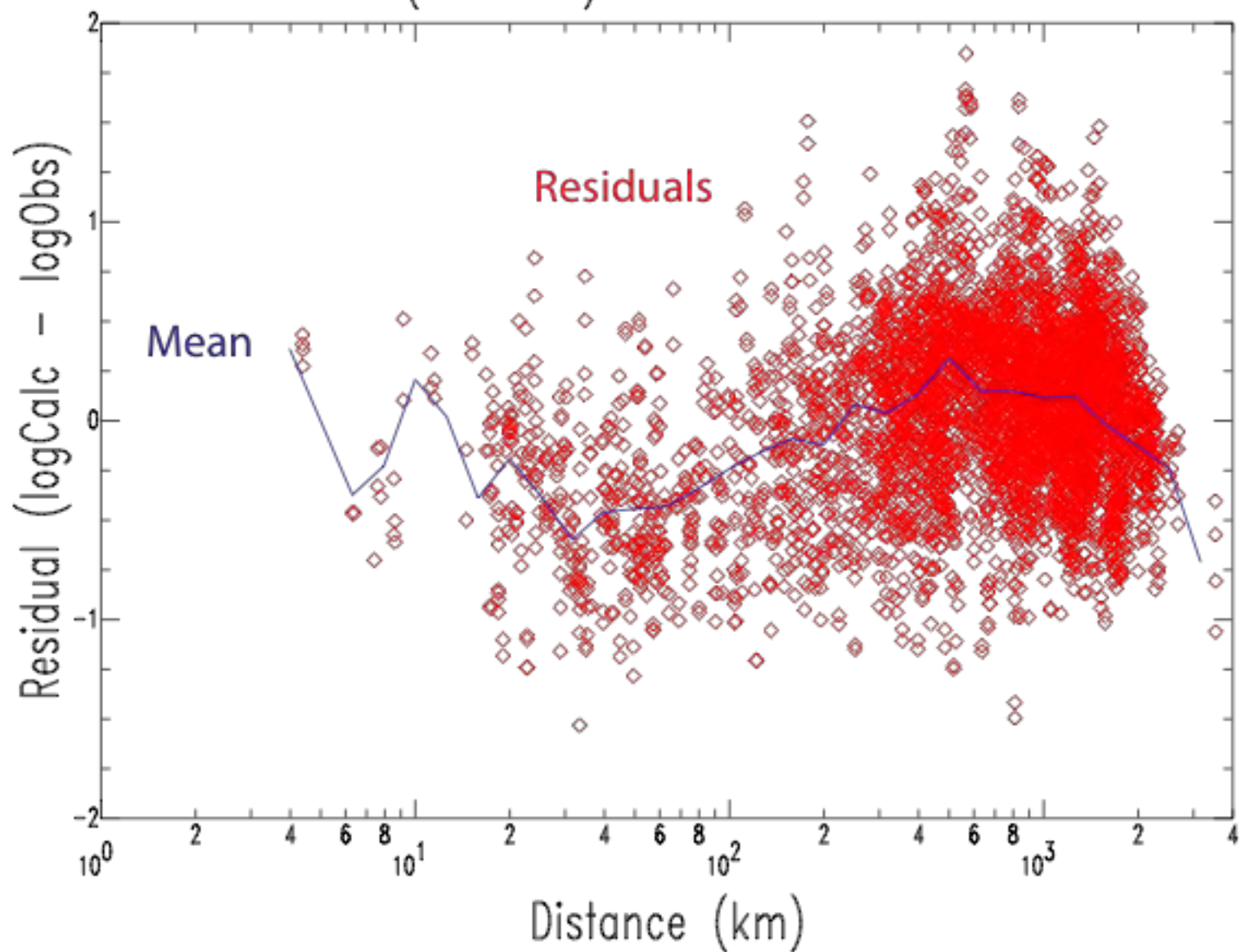
Geological Information (USGS Geologic Map, GSC station book) and Sediment Thickness



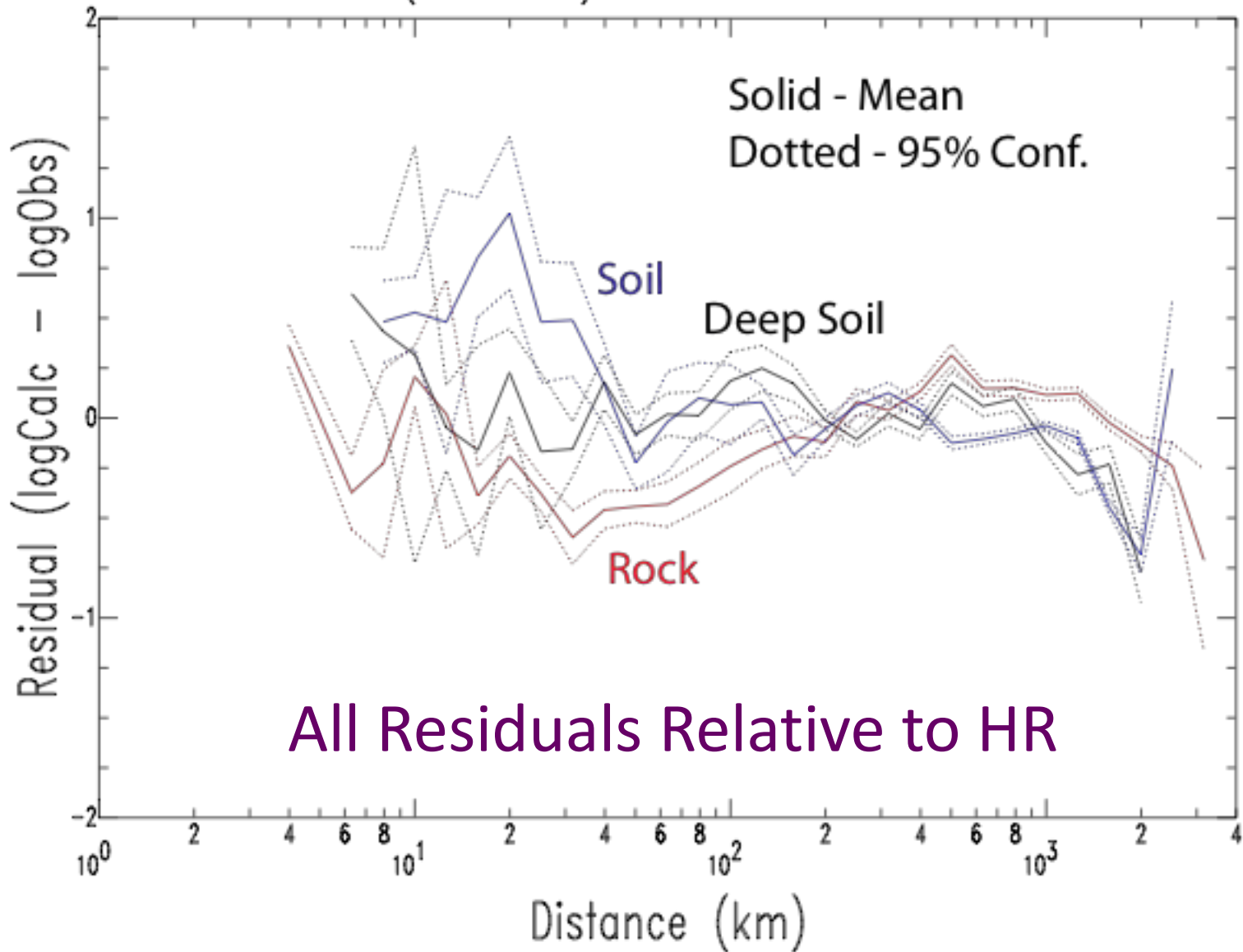
# Residual Analysis Approach

- Form  $\log(\text{Calc})$  minus  $\log(\text{Obs})$  residuals
- Can adjust for soil condition at site (HR or B/C)
- Determine mean, standard deviation, and 95% confidence limits for 0.1  $\log(\text{dist})$  bins.
- Compare mean residuals for distances  $< 100$  km

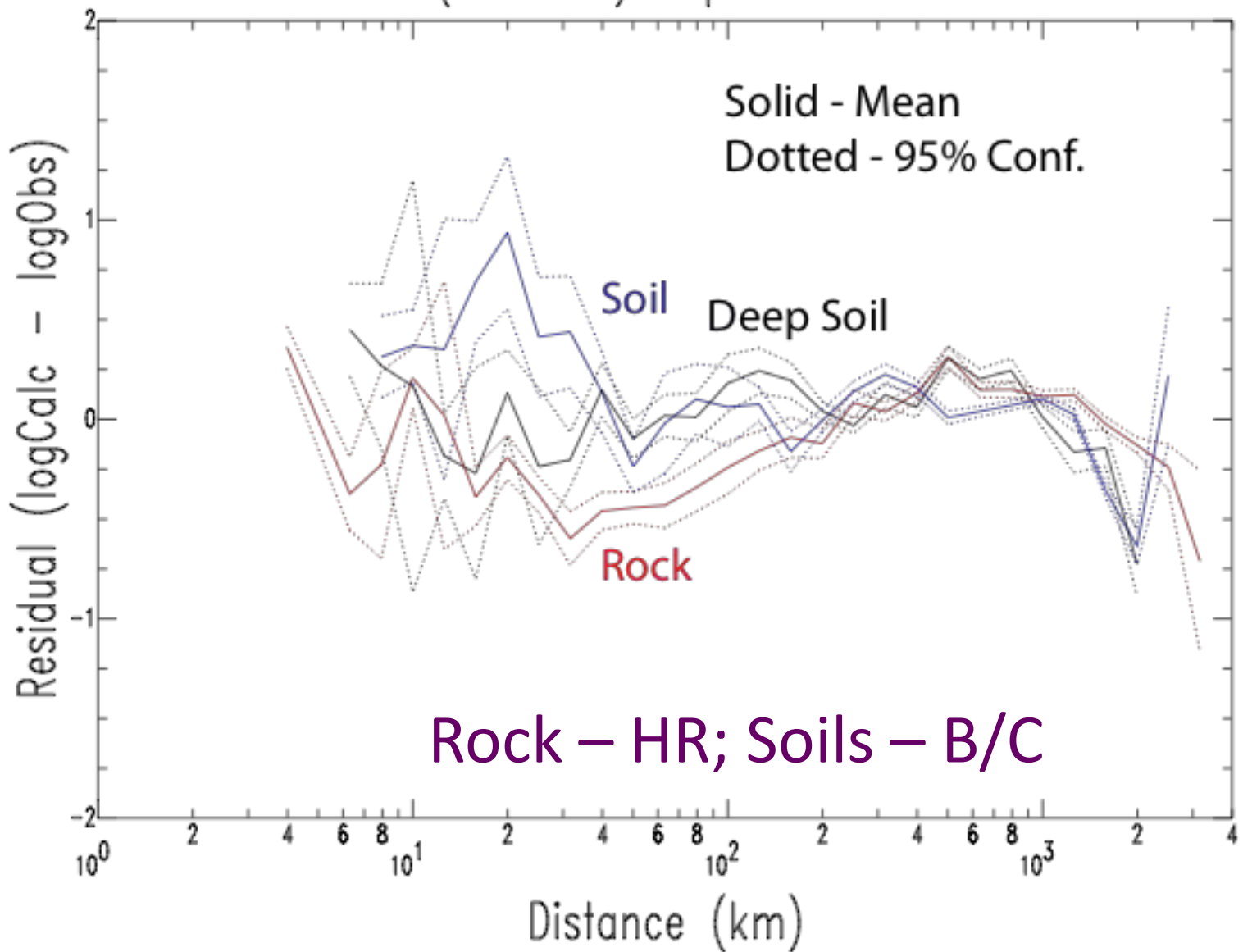
# AB06+ (200 bar) HR SeIR PGA Residuals



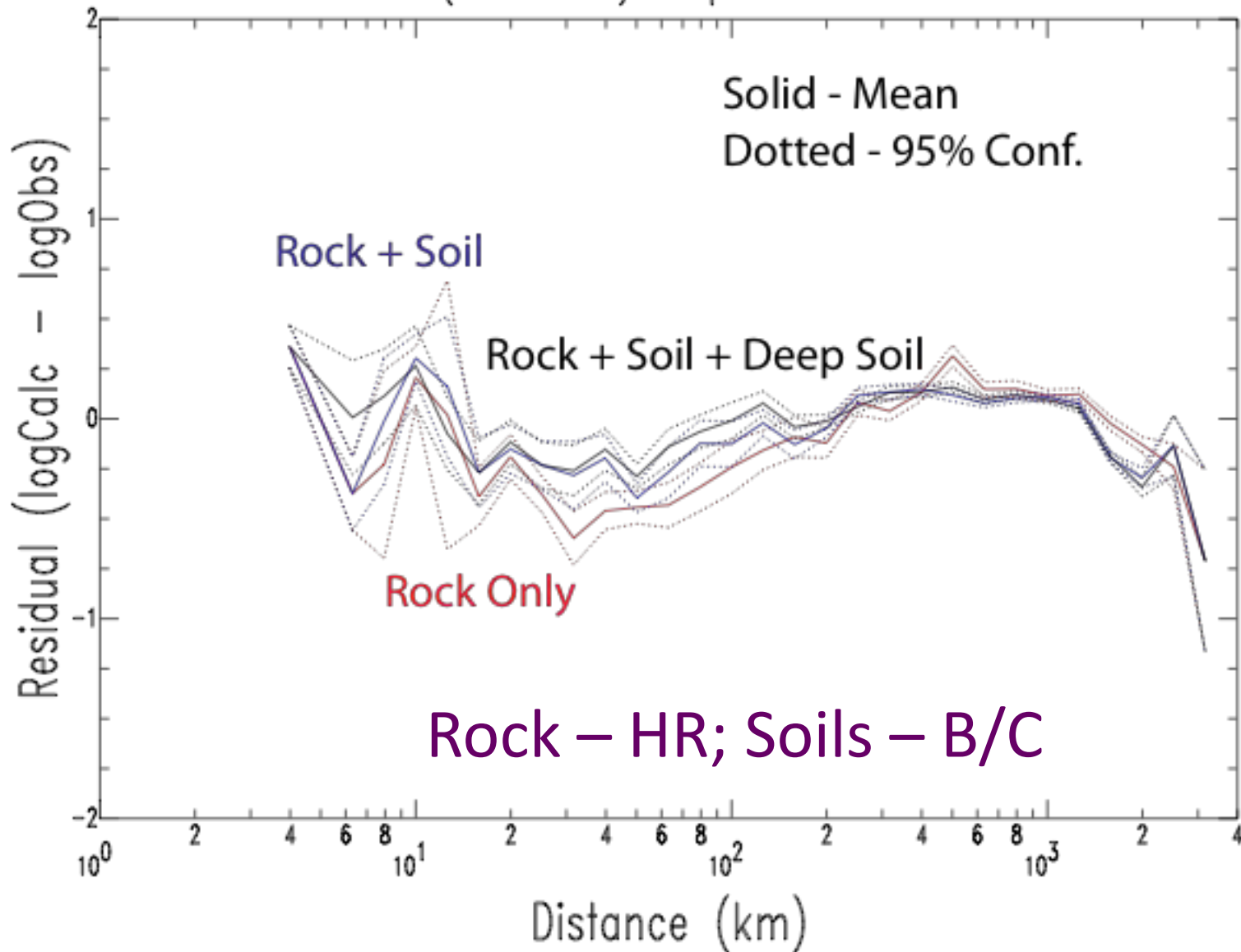
# AB06 (200 bar) HR Sel PGA Residuals



# AB06 (200 bar) Adj PGA Residuals



# AB06 (200 bar) Adj PGA Residuals



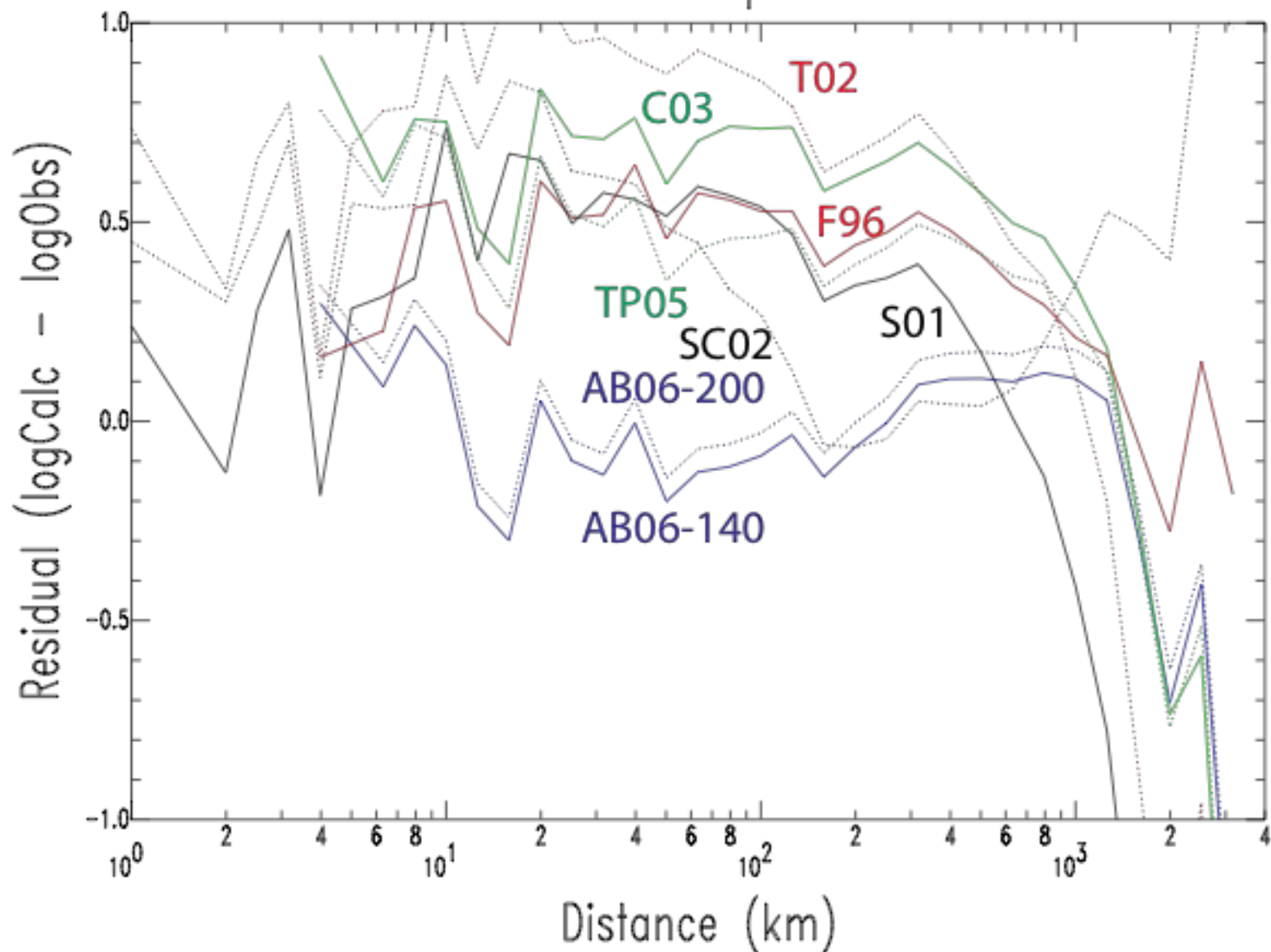


# Results

- GMPEs used in 2008 USGS NSHMP maps
- Newer GMPEs
- Summary Table



# GS08 Alternatives Adj 0.2s Residuals

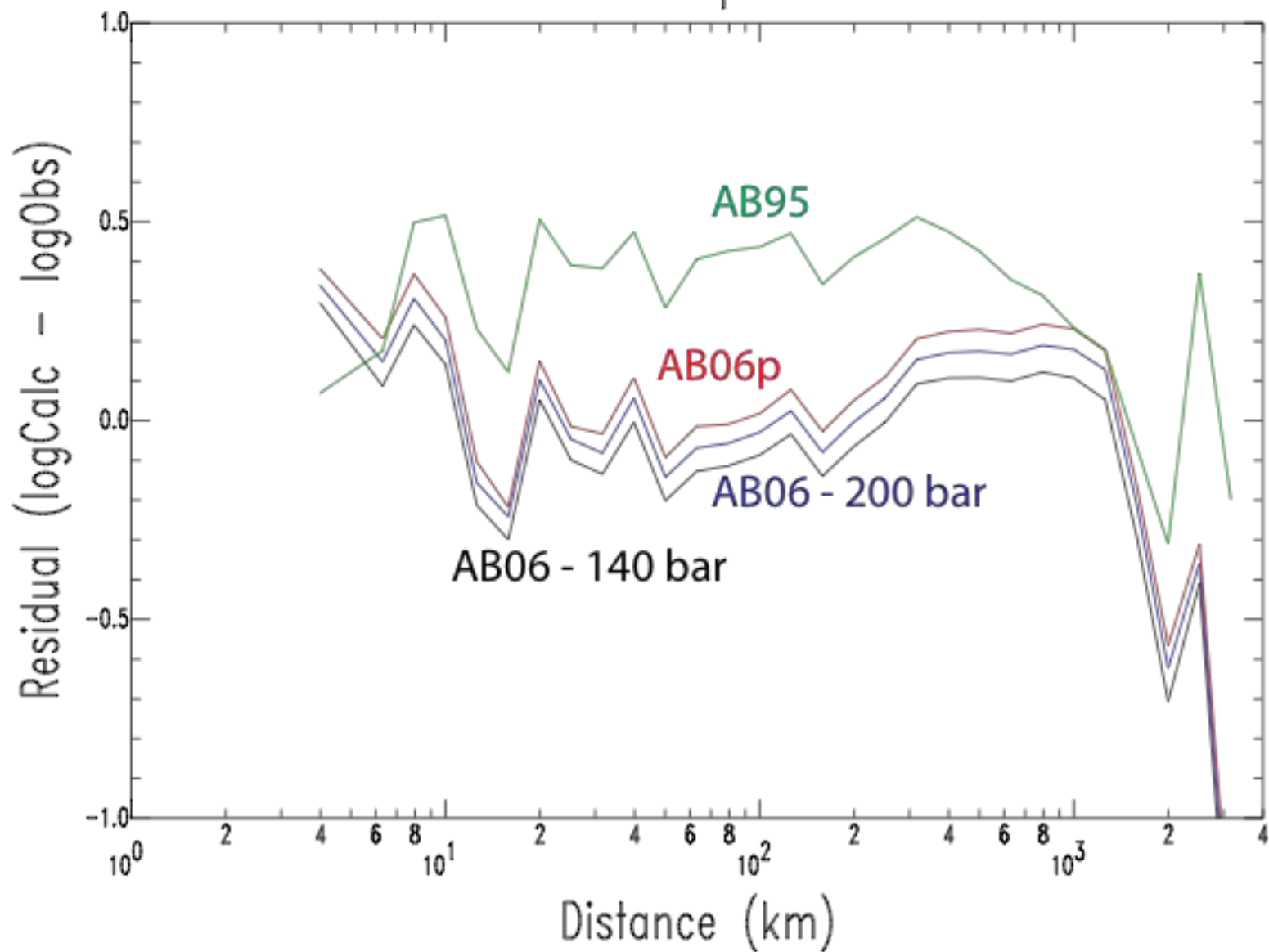




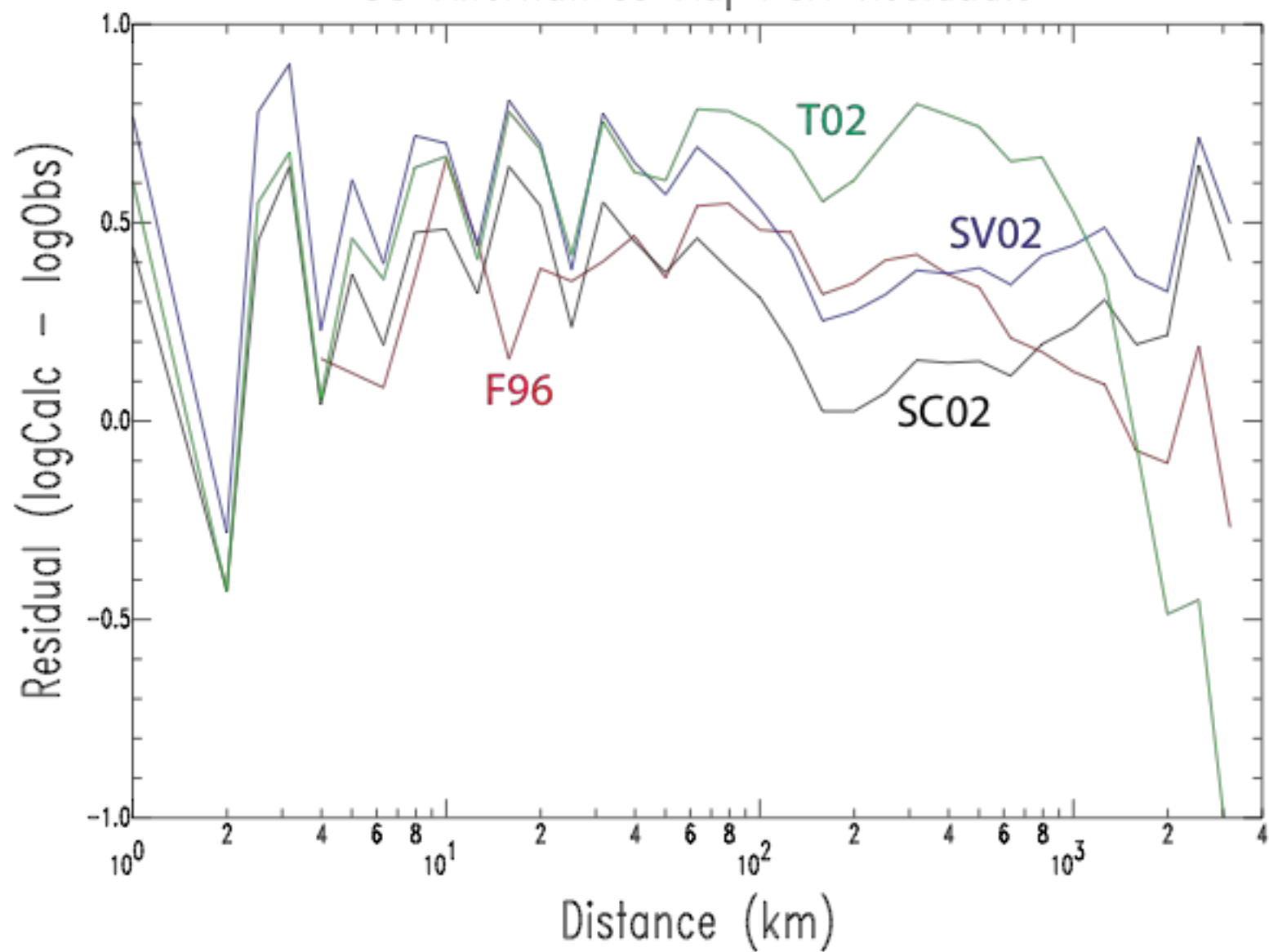
# Newer GMPEs

- AB06p (magnitude dependent  $\Delta\sigma$ ) has slightly more positive residuals and matches observations better than AB06.
- SV02 (Silva single corner, variable  $\Delta\sigma$ ) has slightly more positive residuals than SC02 (single corner, constant  $\Delta\sigma$ , saturated) but not better match to observations.
- SD02 (Silva double corner, saturated) has more positive residuals than AB06p but strongly under predicts beyond 100 km unlike AB06p, except at short period where equal.
- PZT11 has more negative residuals than C03 and TP05 but is not always better than TP05 at matching observations.

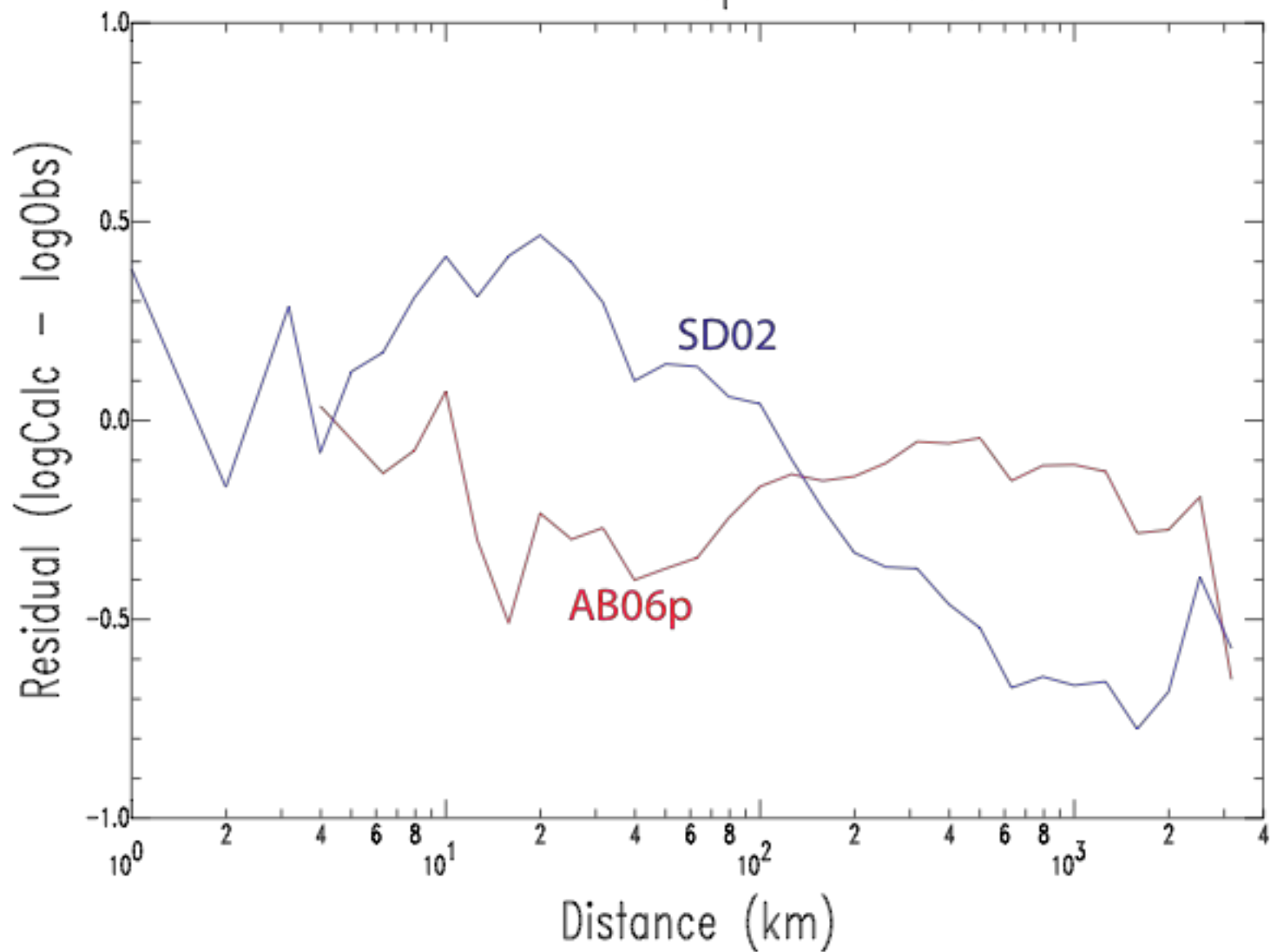
# AB Alternatives Adj 0.2s Residuals



# SC Alternatives Adj PGA Residuals

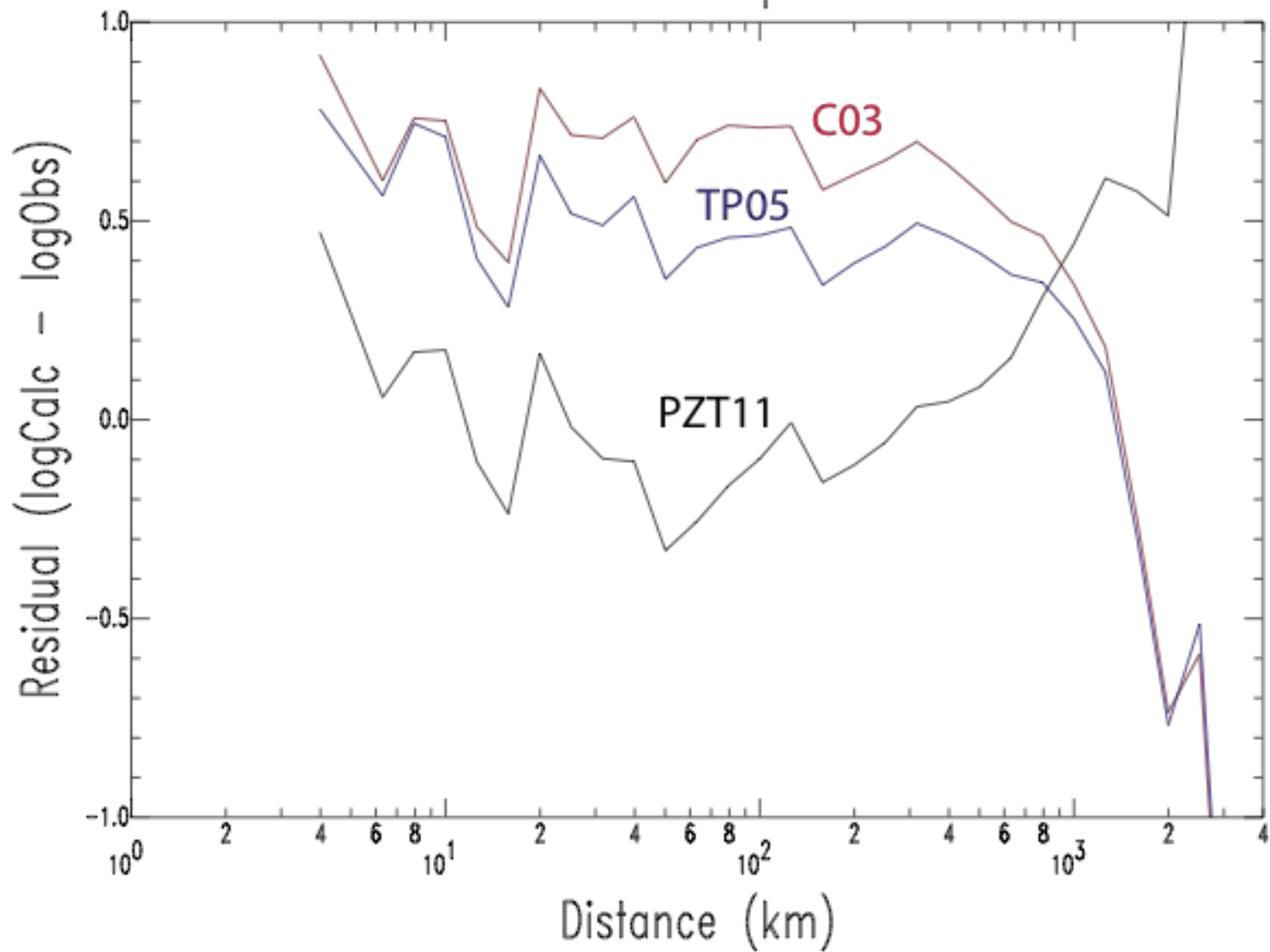


# DC Alternatives Adj 1.0s Residuals





# HYBRID Alternatives Adj 0.2s Residuals



# Summary Table

**Table 1: Mean residuals for distance  $\leq 100$ km for three periods. Factor is average of the absolute value of the three mean residuals. Numbers in parentheses are number of observations at each period.**

<u>GMPE</u>	<u>PGA (867)</u>	<u>0.2s(852)</u>	<u>1.0s(750)</u>	<u>Factor</u>
AB06p	-0.096	0.005	-0.313	0.138
AB06+	-0.162	-0.043	-0.334	0.180
AB06	-0.241	-0.100	-0.364	0.235
EPRI4	0.139	0.408	0.197	0.248
EPRI2	0.336	0.278	0.196	0.270
TP05	0.120	0.477	0.224	0.274
AB95	0.379	0.381	0.080	0.280
EPRI1	0.311	0.372	0.174	0.286
S01	0.232	0.534	0.265	0.344
PZT11	-0.634	-0.138	0.309	0.361
F96	0.428	0.517	0.151	0.365
SC02	0.424	0.547	0.227	0.399
SD02	0.518	0.537	0.199	0.418
EPRI3	0.522	0.476	0.344	0.448
SV02	0.628	0.658	0.178	0.488
C03	0.577	0.690	0.401	0.556
T02	0.654	0.913	0.608	0.725



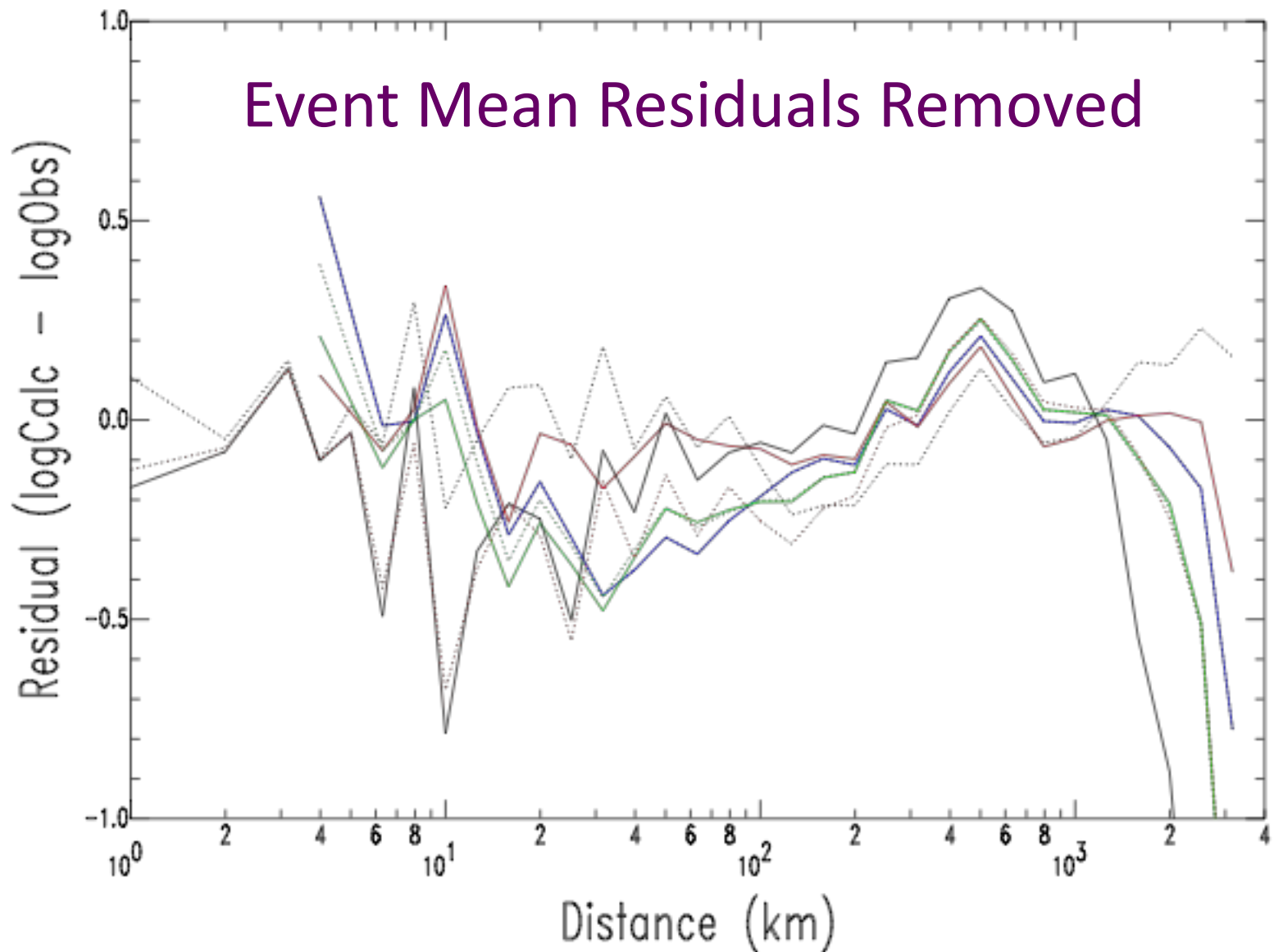
# Correct for Event Terms?

- Removing event mean residuals focuses on intra-event variability and homogenized GMPEs (bad).
- Correcting event mean residuals to a single event's mean for that GMPE maintains more of relationships among GMPEs. Choice of reference event shifts residuals up or down relative to zero. Non-uniform sampling among events introduces bias with distance (better but ?).
- Chose not to correct for event terms at this time.



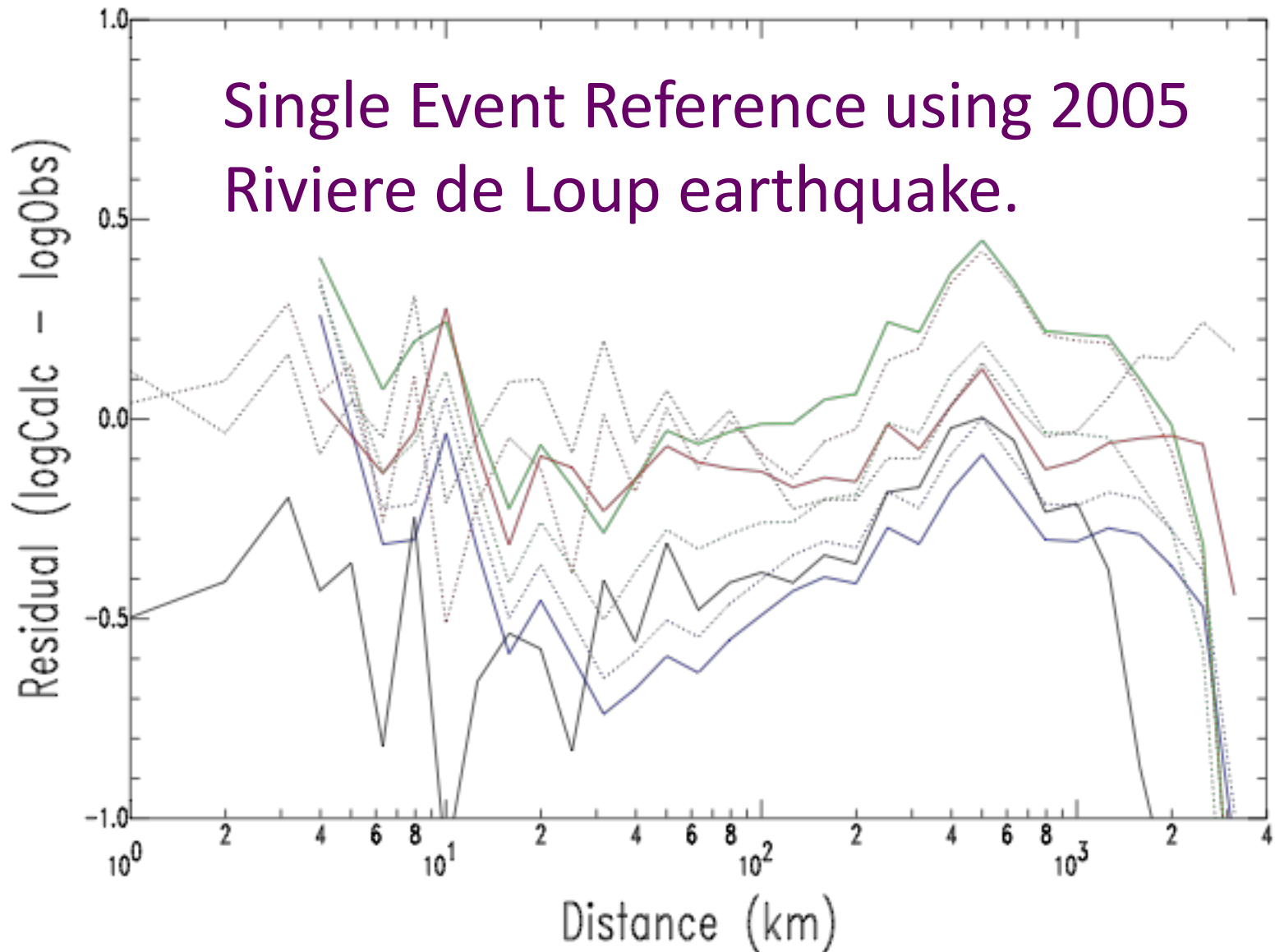
# GS08 HR Alternatives SelReav PGA Residuals

Event Mean Residuals Removed



# GS08 HR Alternatives SelR1ev PGA Residuals

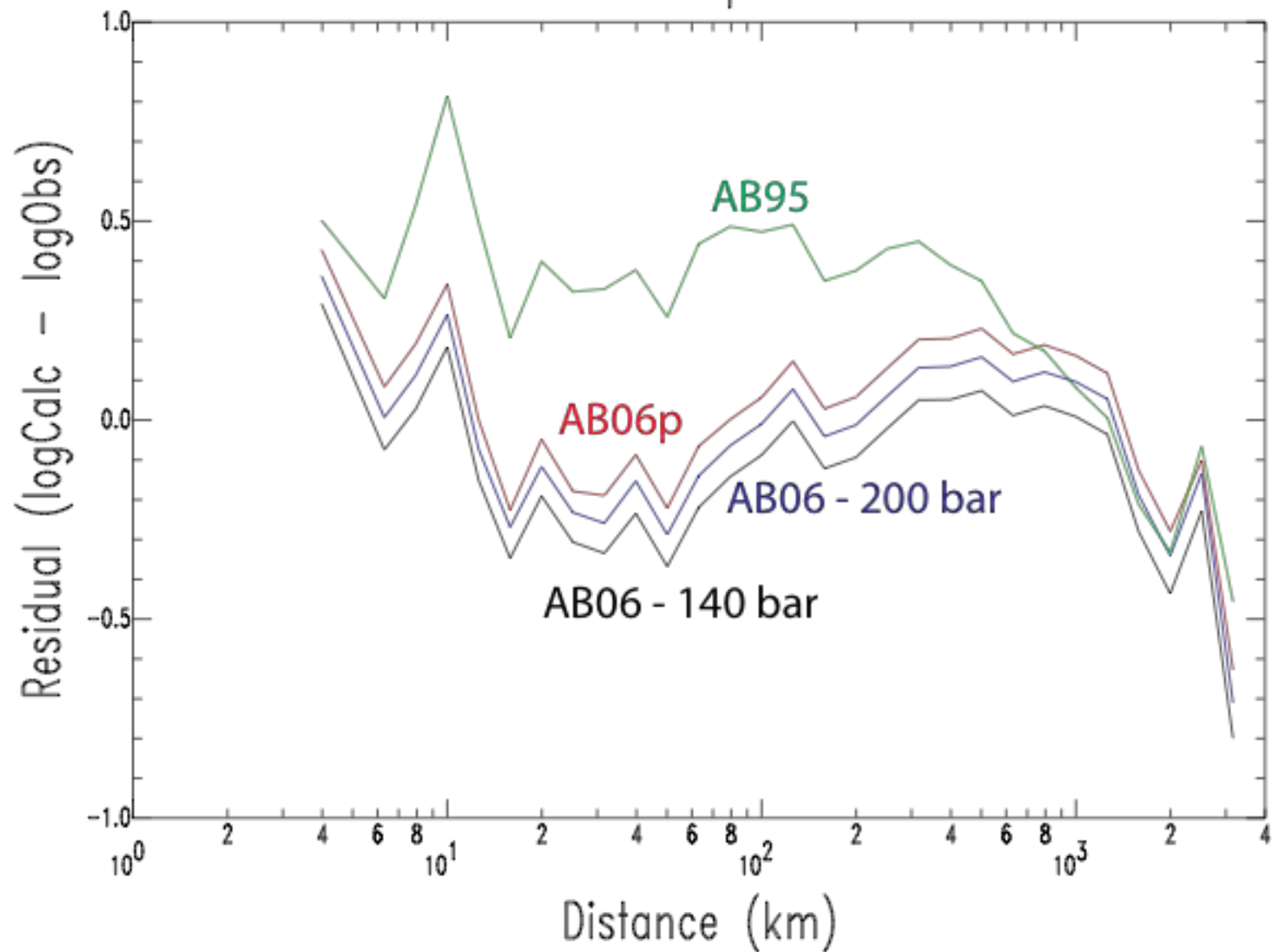
Single Event Reference using 2005 Riviere de Loup earthquake.



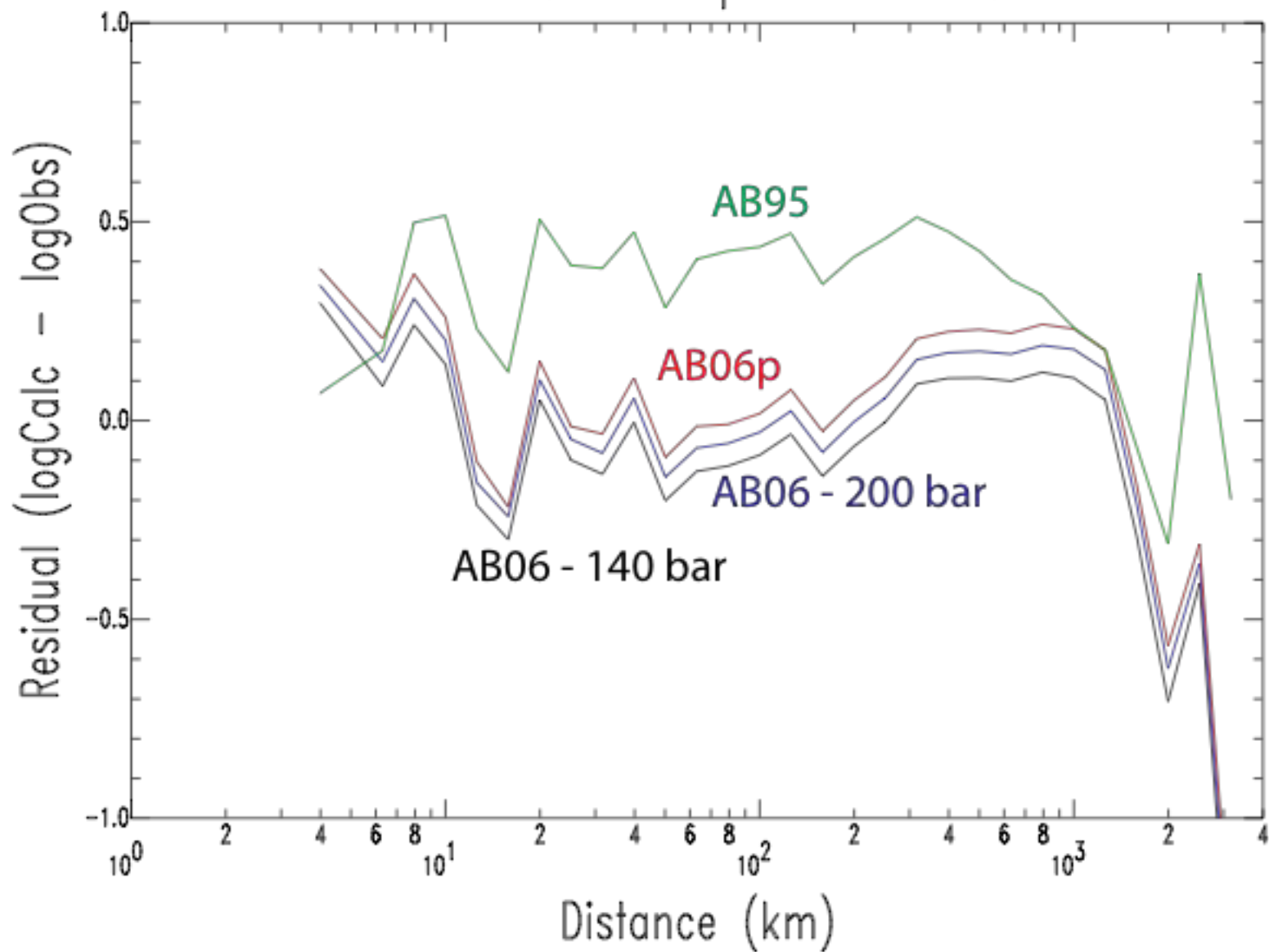
# Atkinson and Boore Alternatives



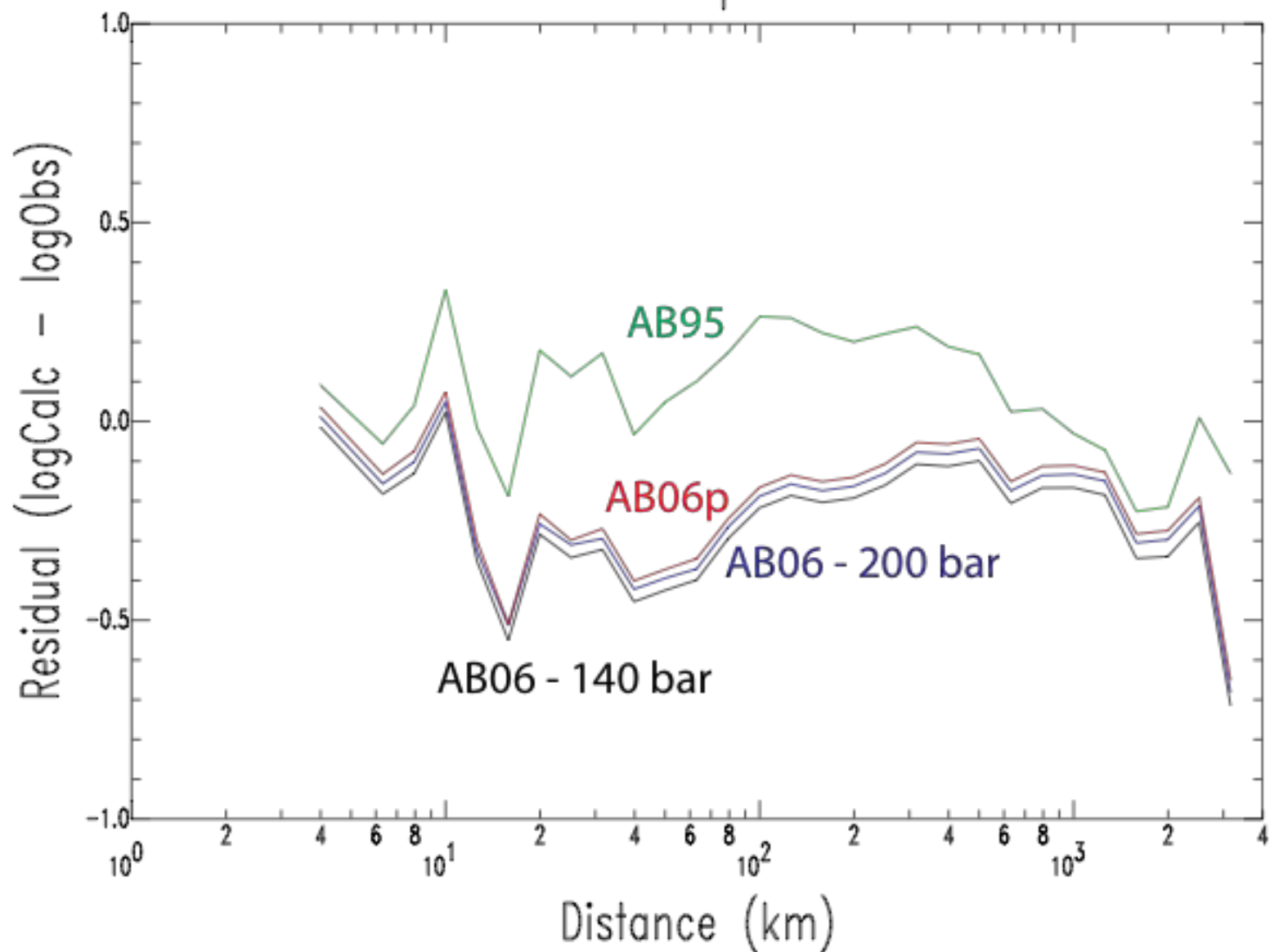
# AB Alternatives Adj PGA Residuals



# AB Alternatives Adj 0.2s Residuals

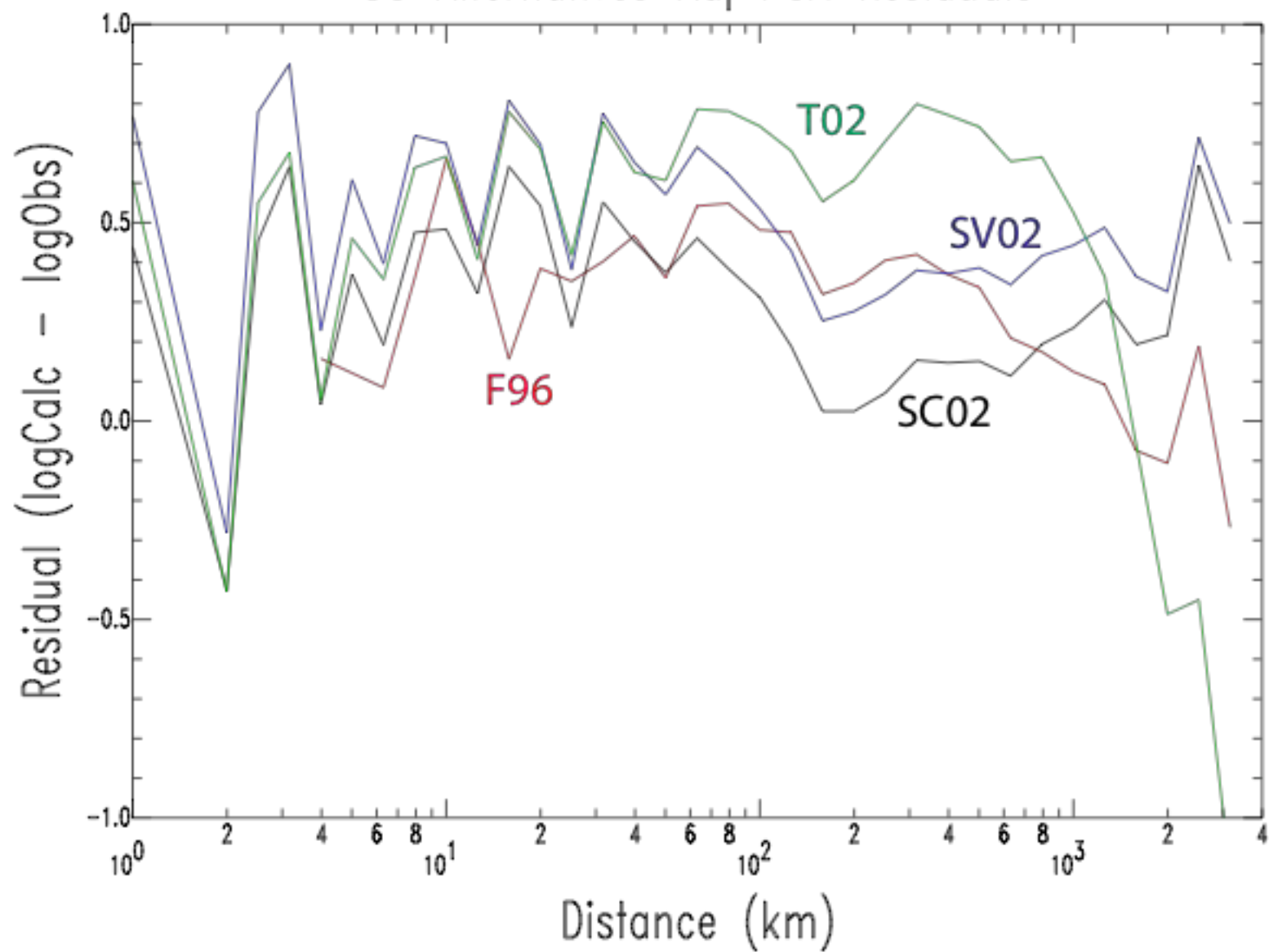


# AB Alternatives Adj 1.0s Residuals

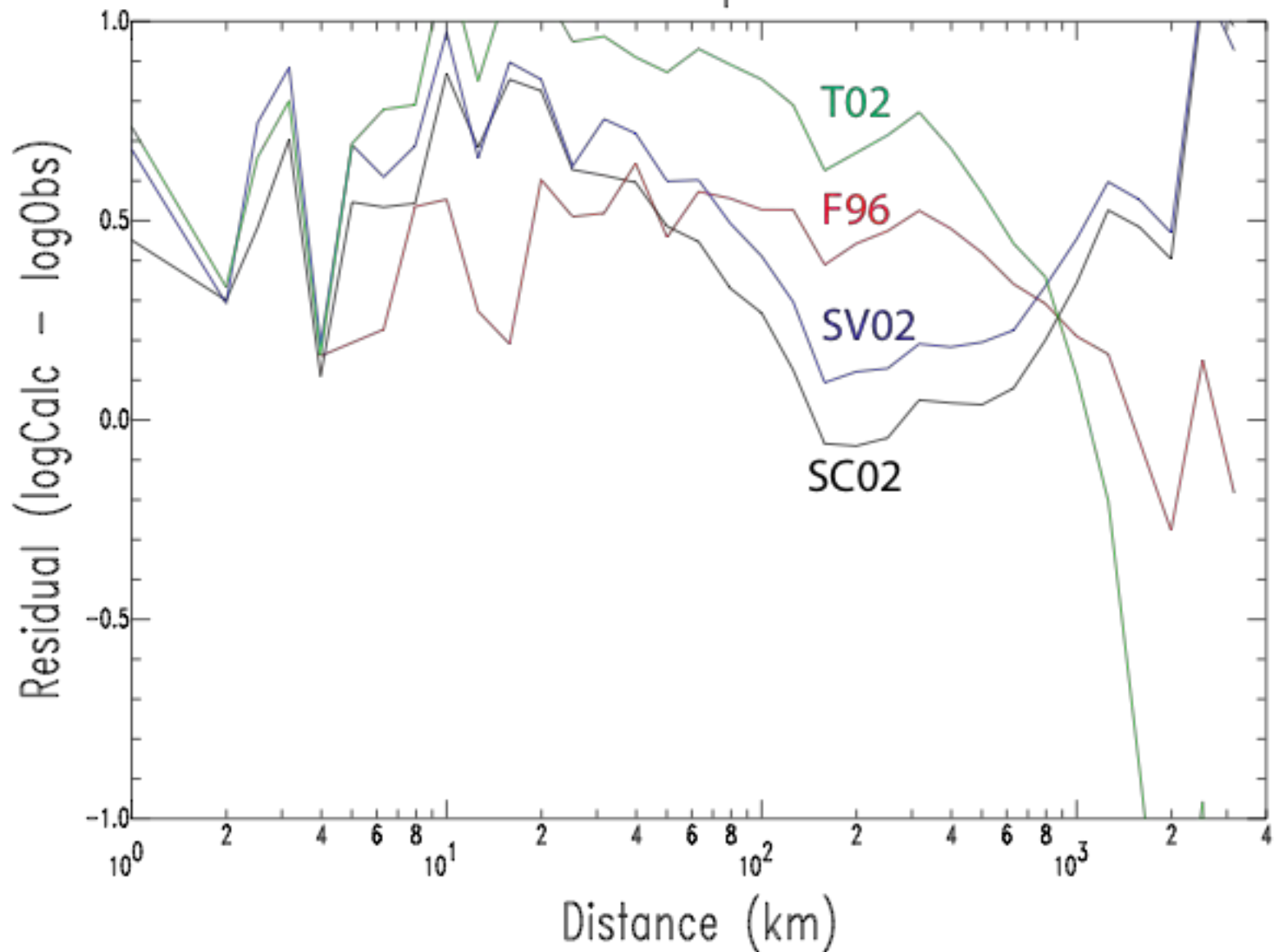


# Single Corner Alternatives

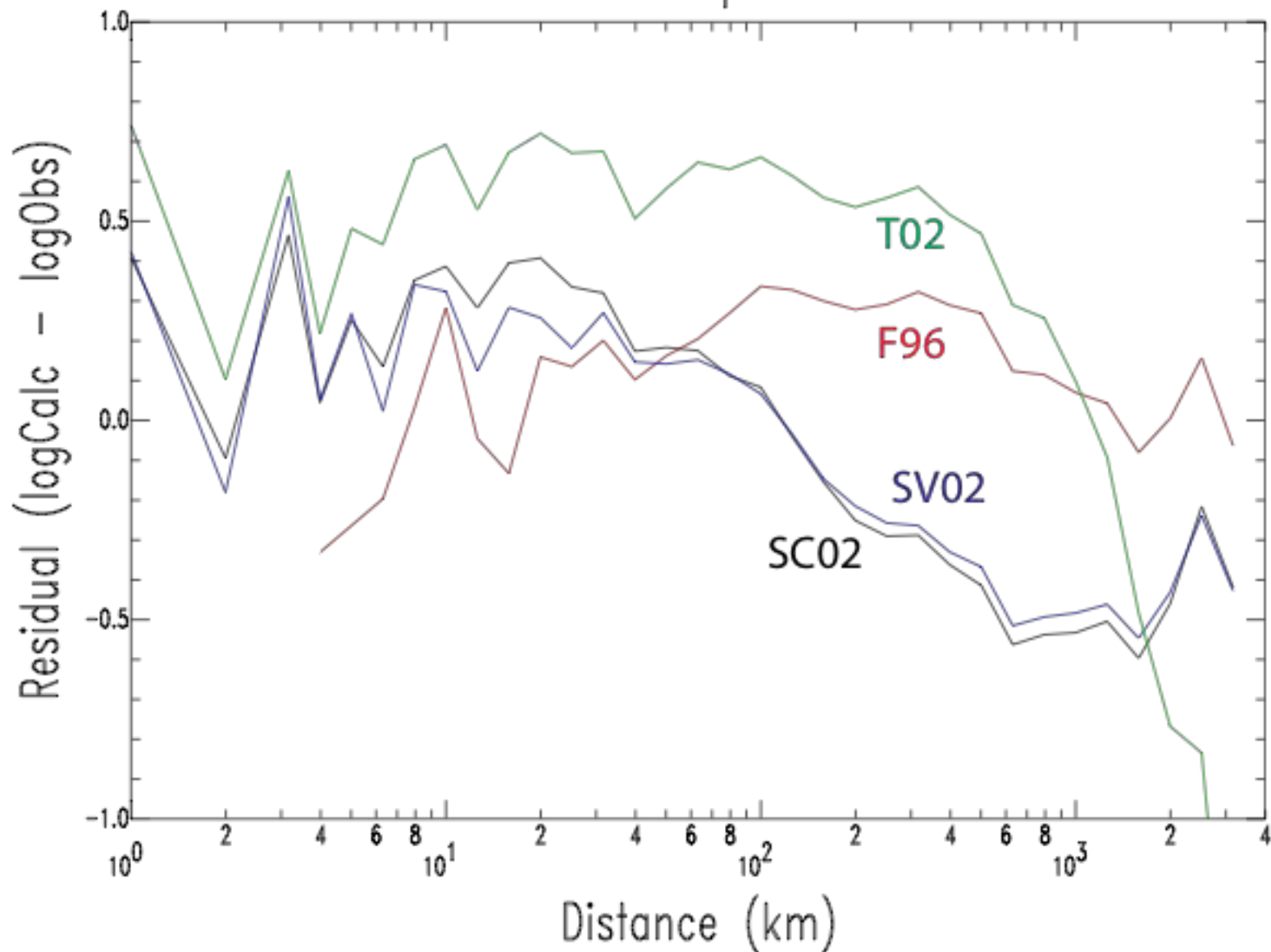
# SC Alternatives Adj PGA Residuals



SC Alternatives Adj 0.2s Residuals



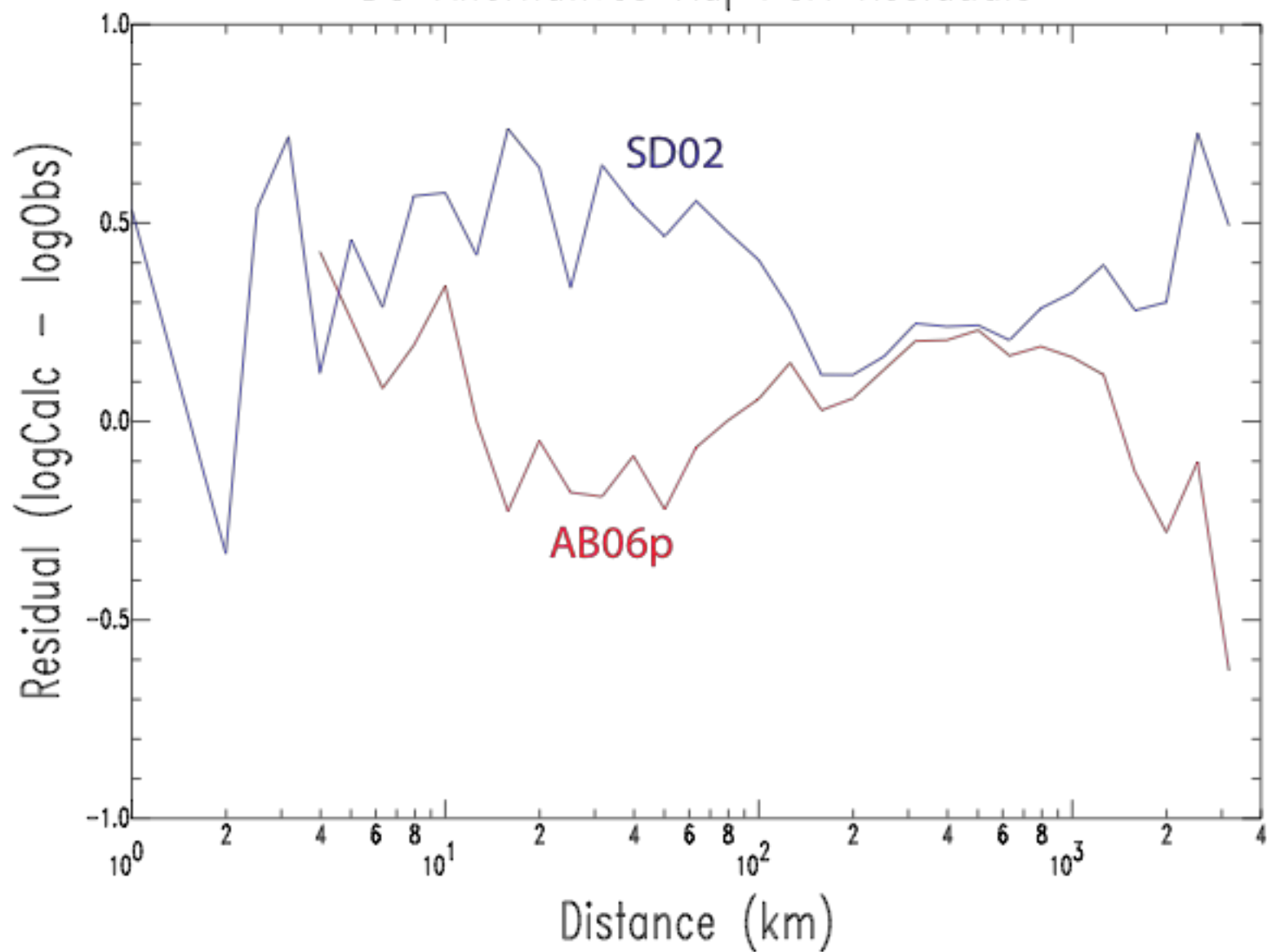
# SC Alternatives Adj 1.0s Residuals



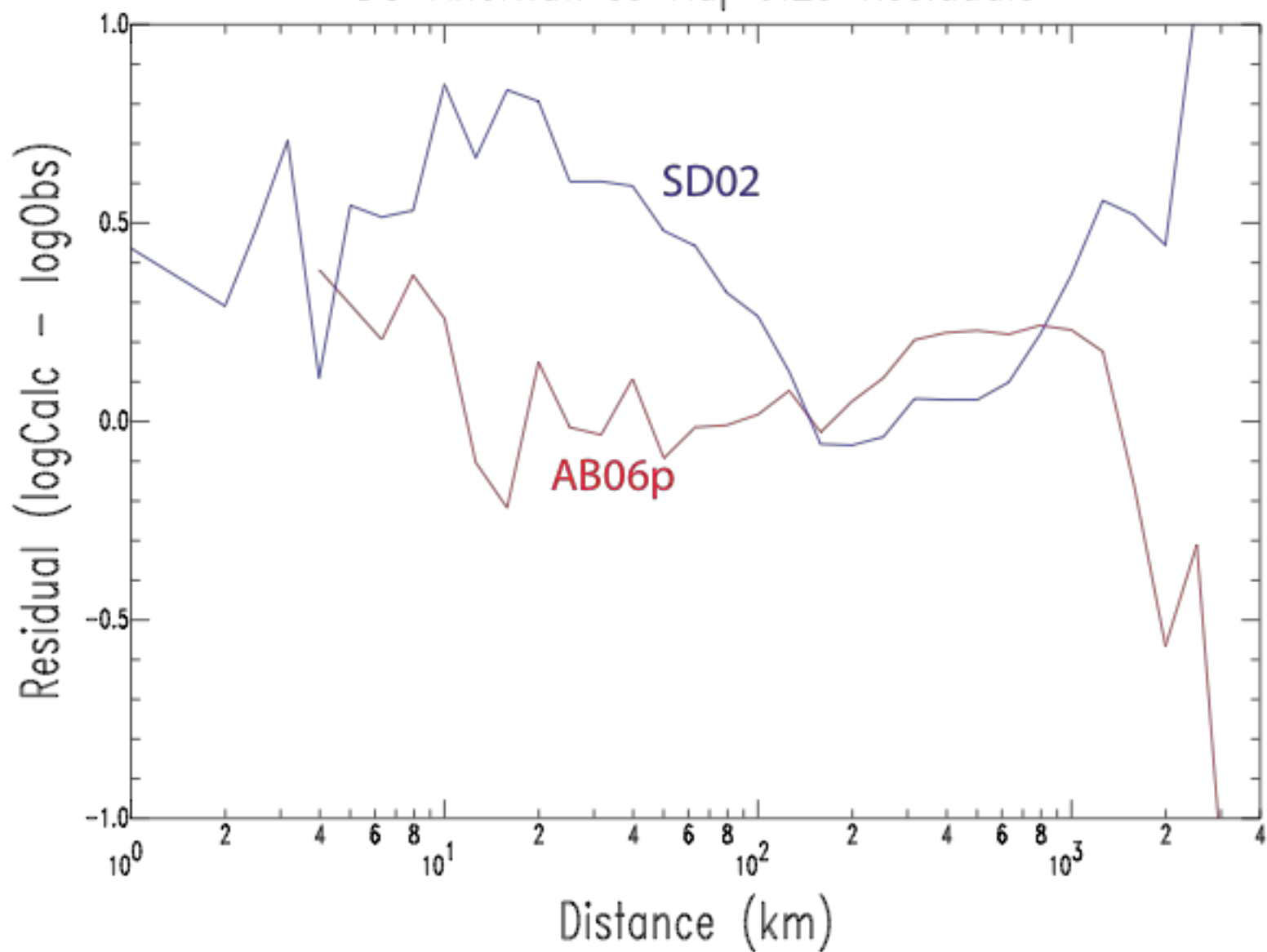
# Double Corner Alternatives



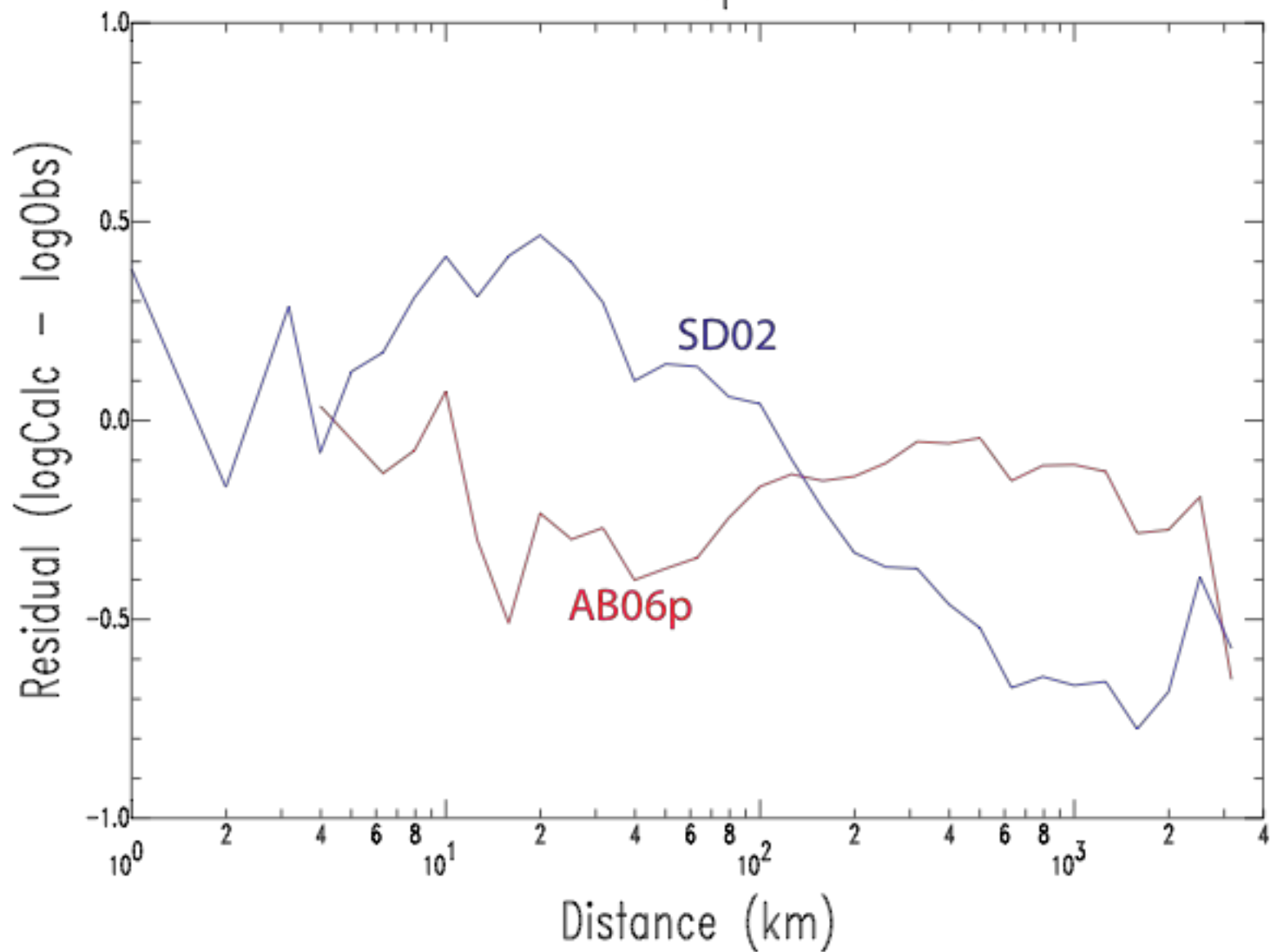
# DC Alternatives Adj PGA Residuals



# DC Alternatives Adj 0.2s Residuals

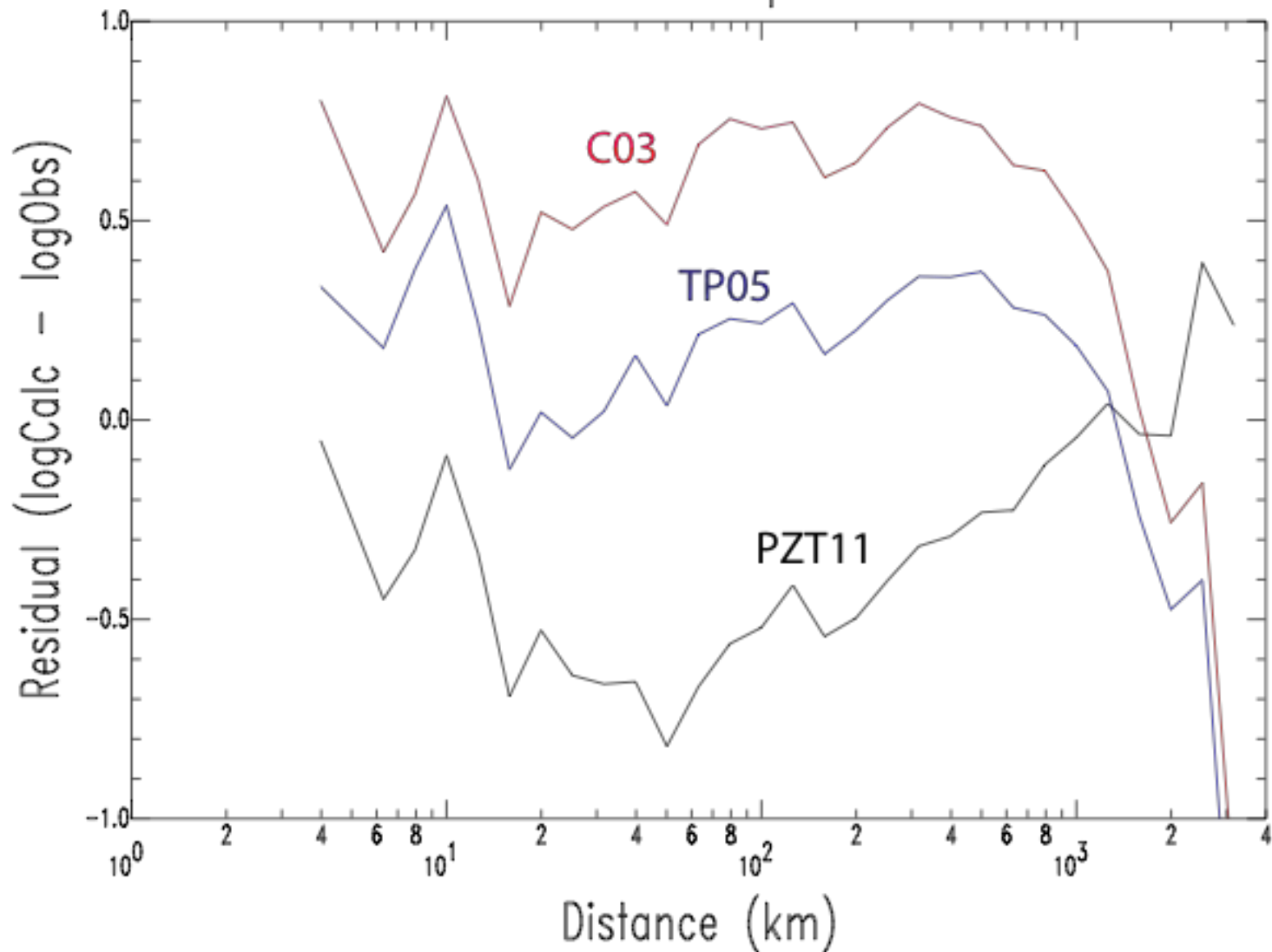


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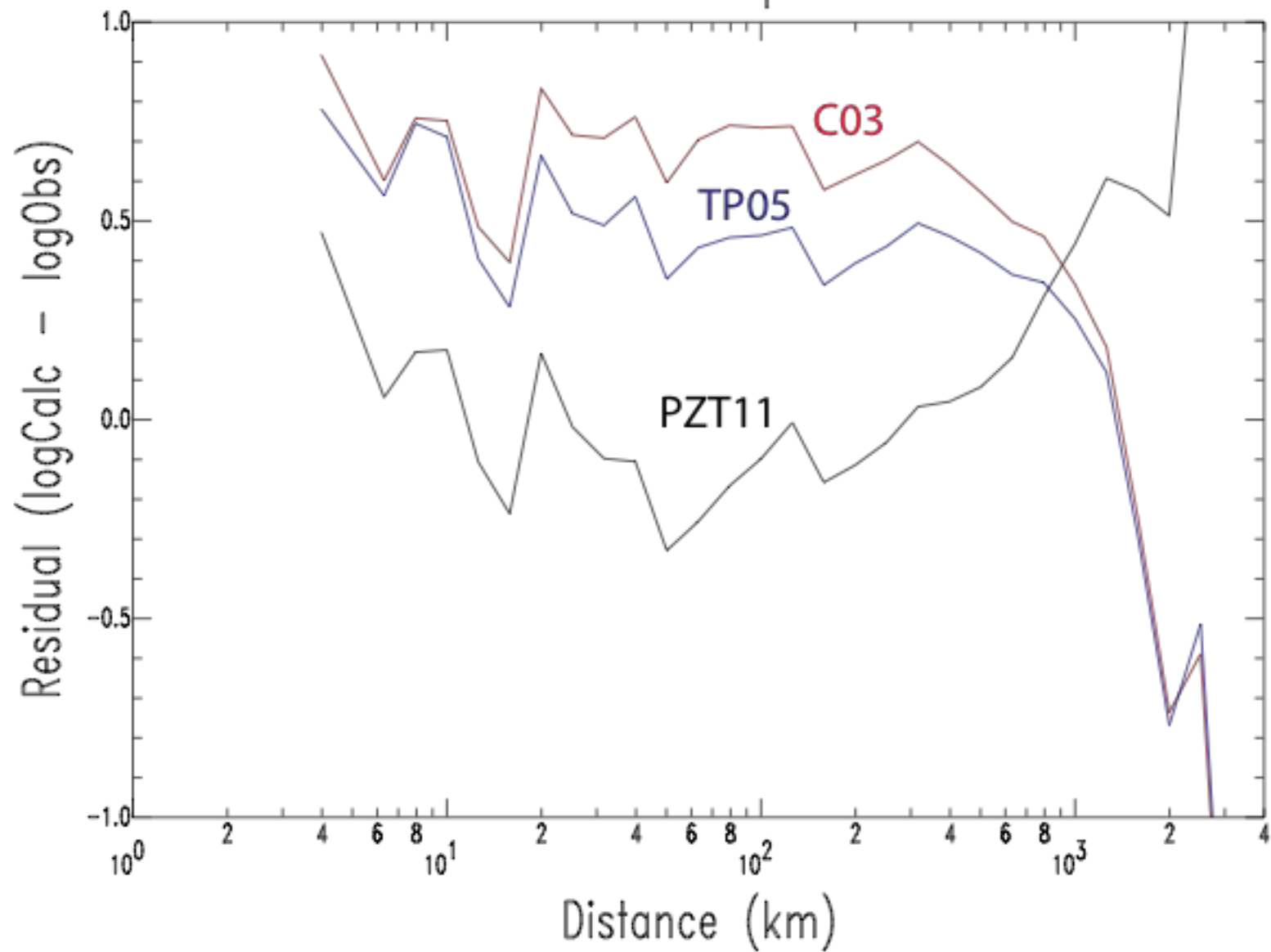


# Hybrid Empirical Alternatives

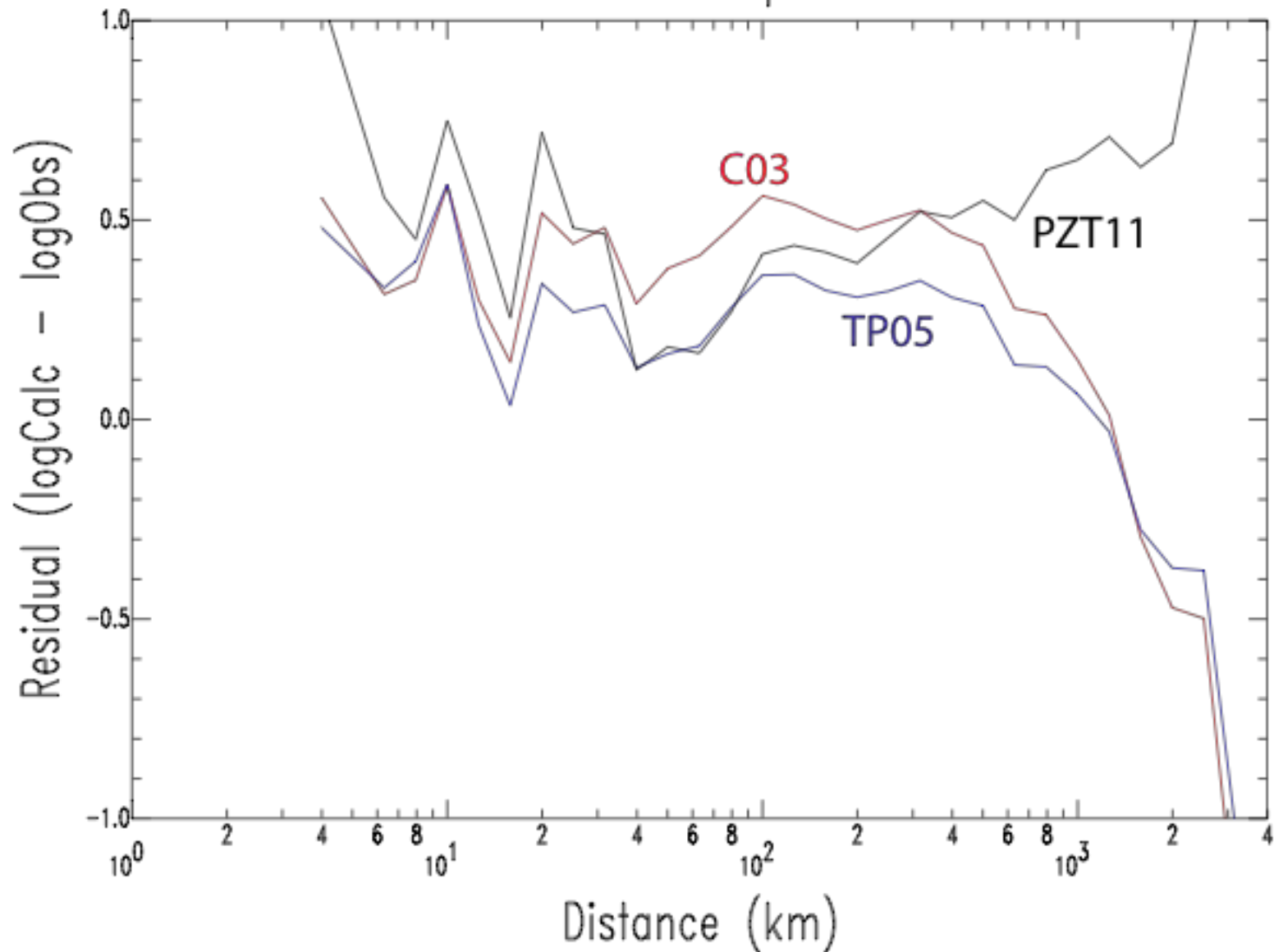
# HYBRID Alternatives Adj PGA Residuals



# HYBRID Alternatives Adj 0.2s Residuals



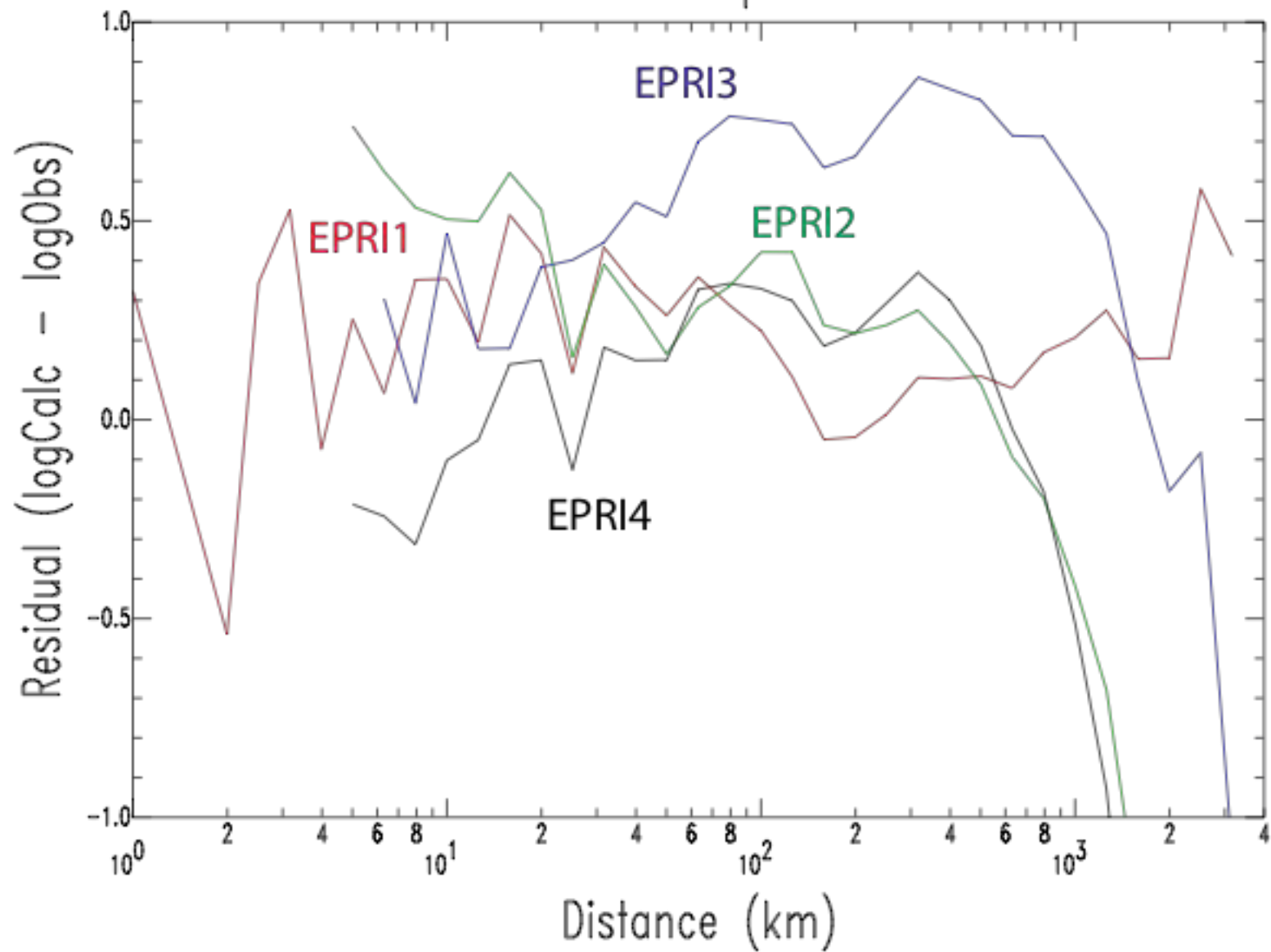
# HYBRID Alternatives Adj 1.0s Residuals



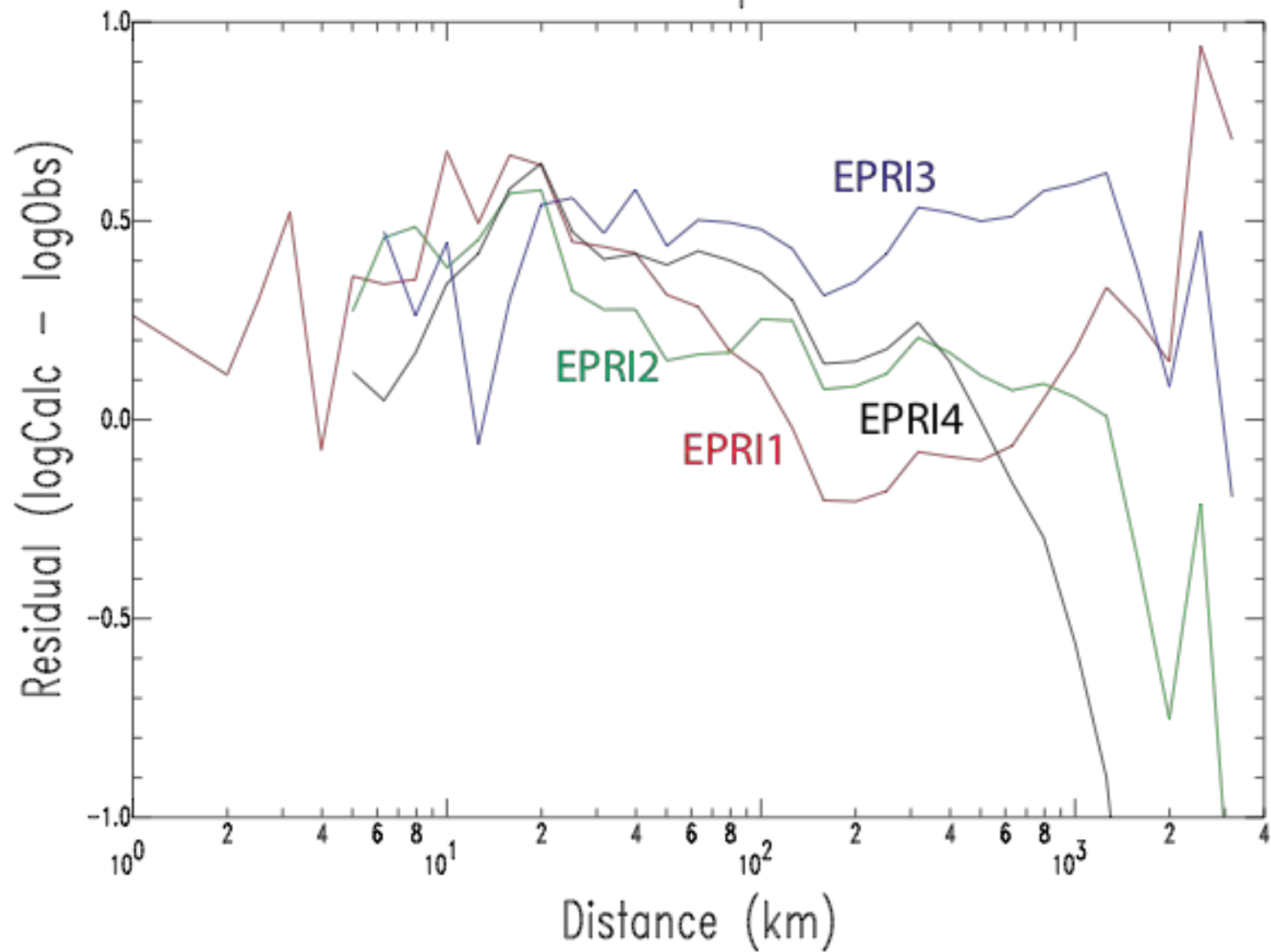
# EPRI 2004 Alternatives



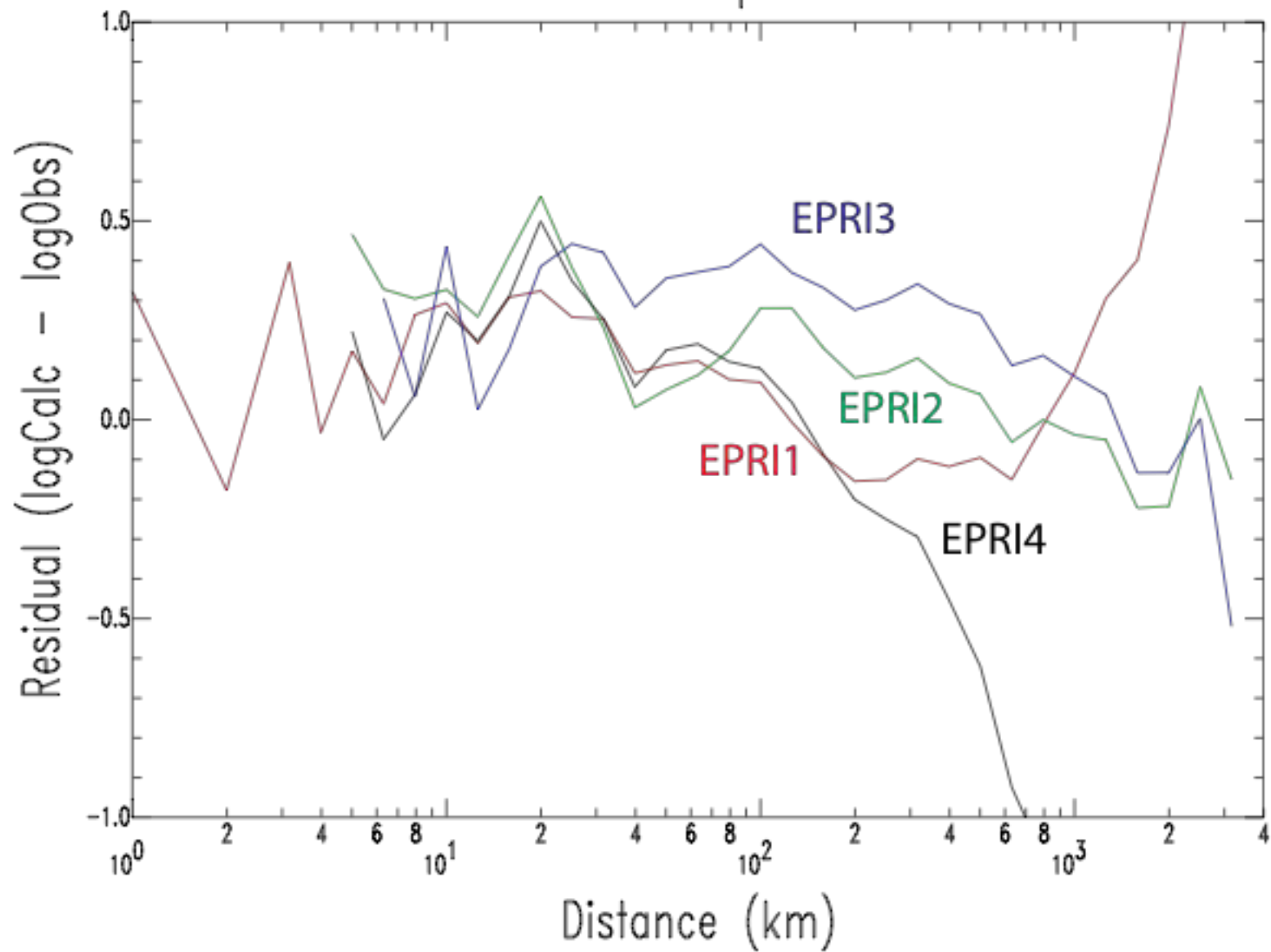
# EPRI Alternatives Adj PGA Residuals



# EPRI Alternatives Adj 0.2s Residuals



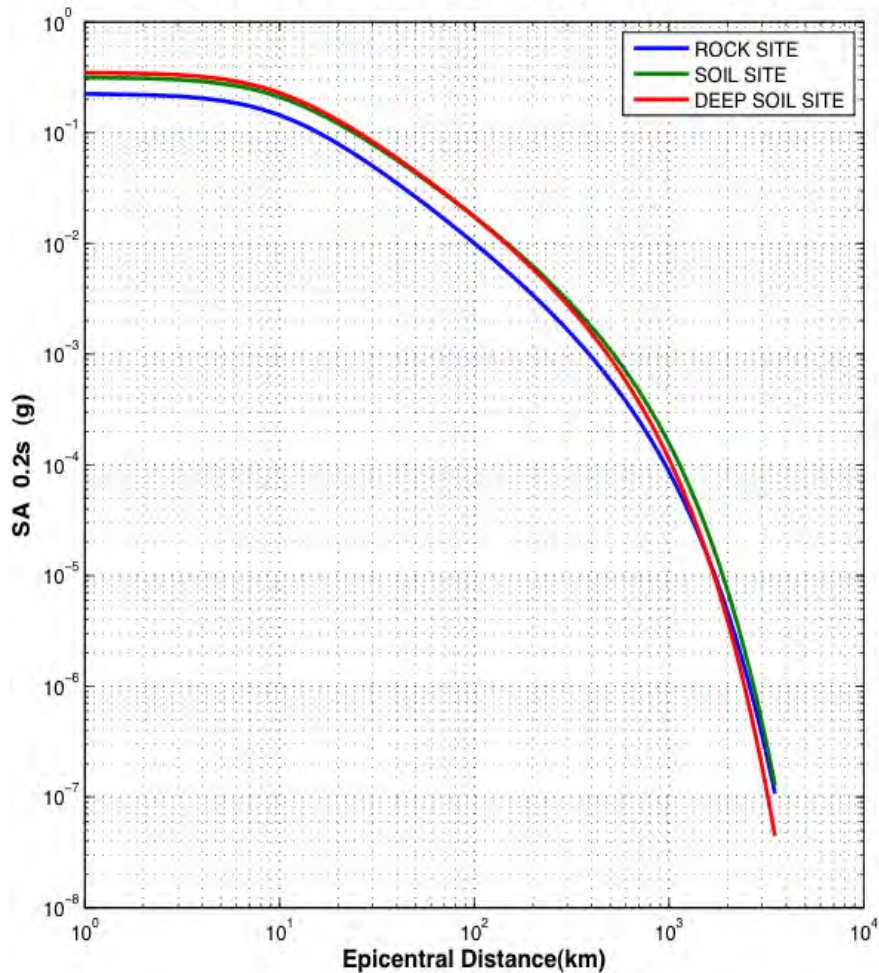
# EPRI Alternatives Adj 1.0s Residuals



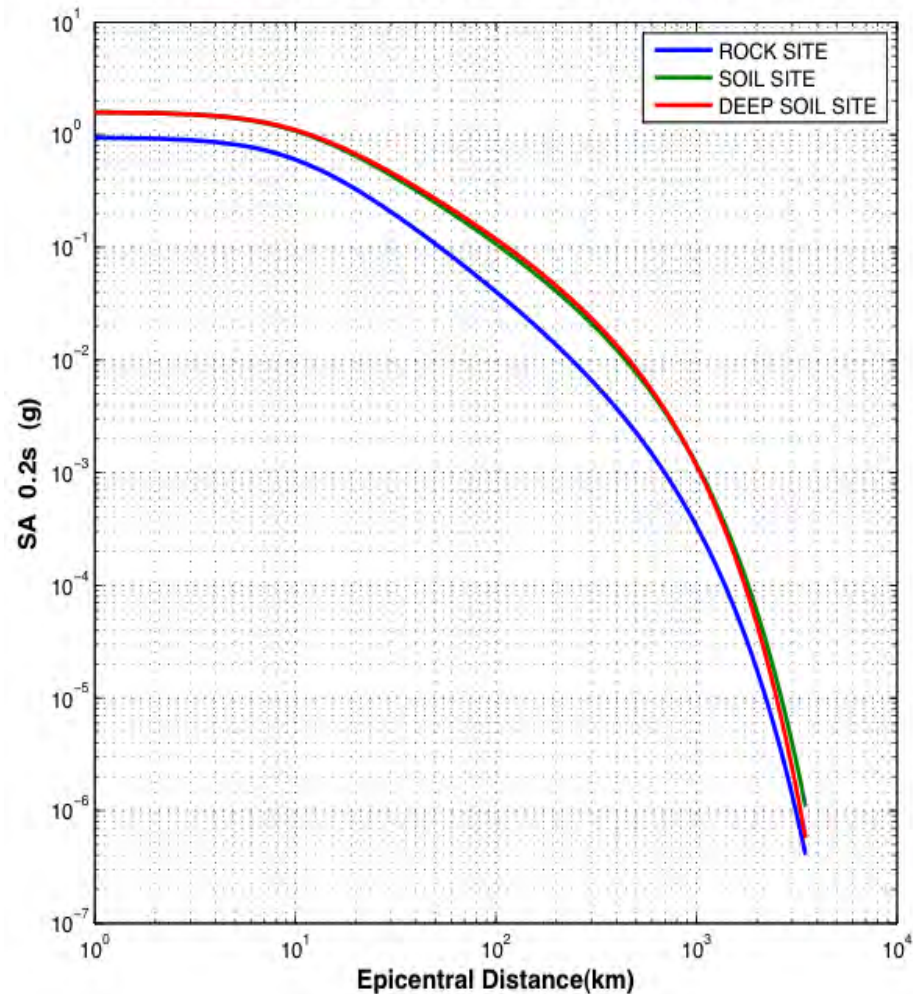


# Attenuation at different site soils at 0.2 sec

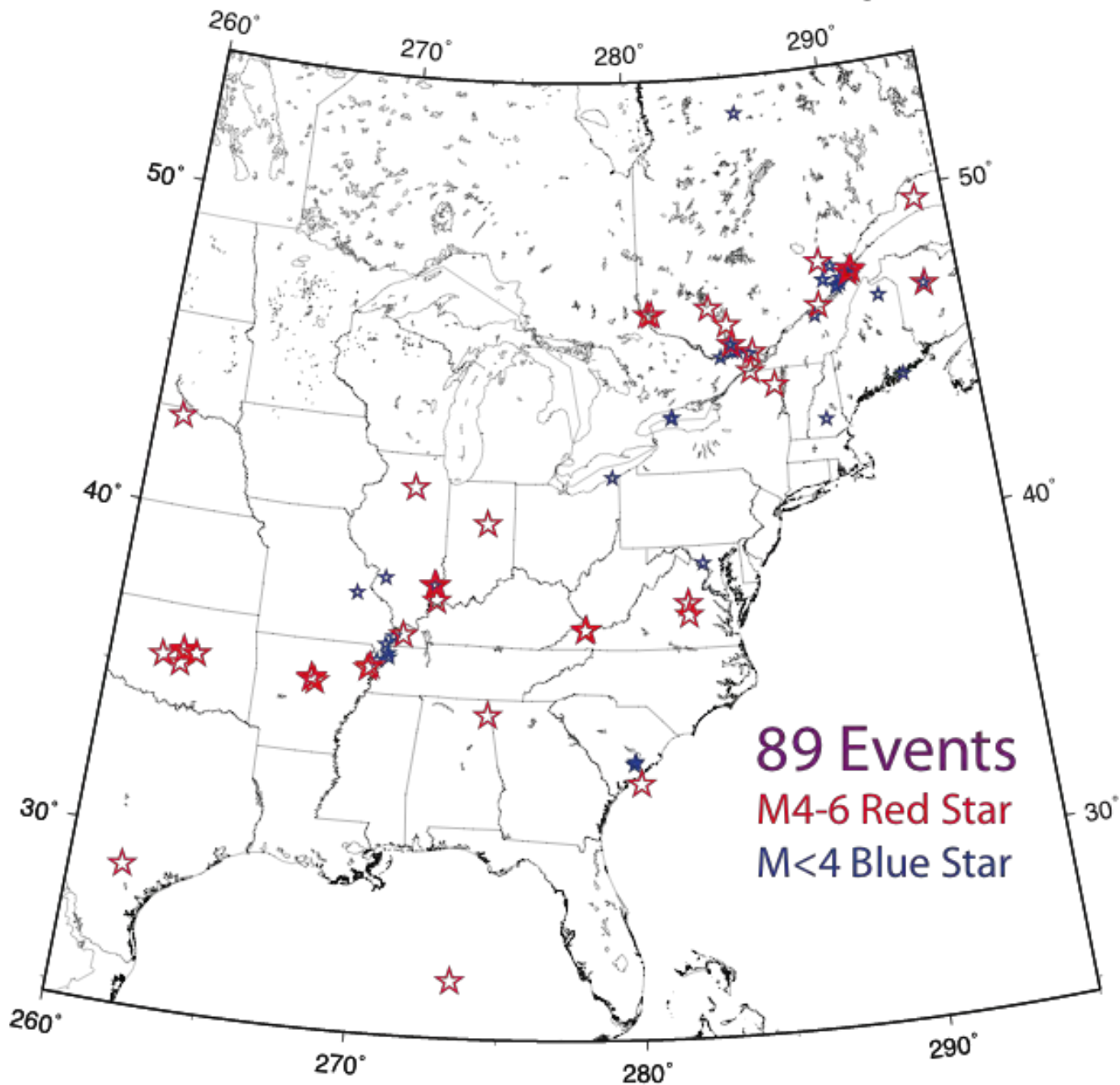
## M 5.0 Attenuation Relations at Different Site Soils



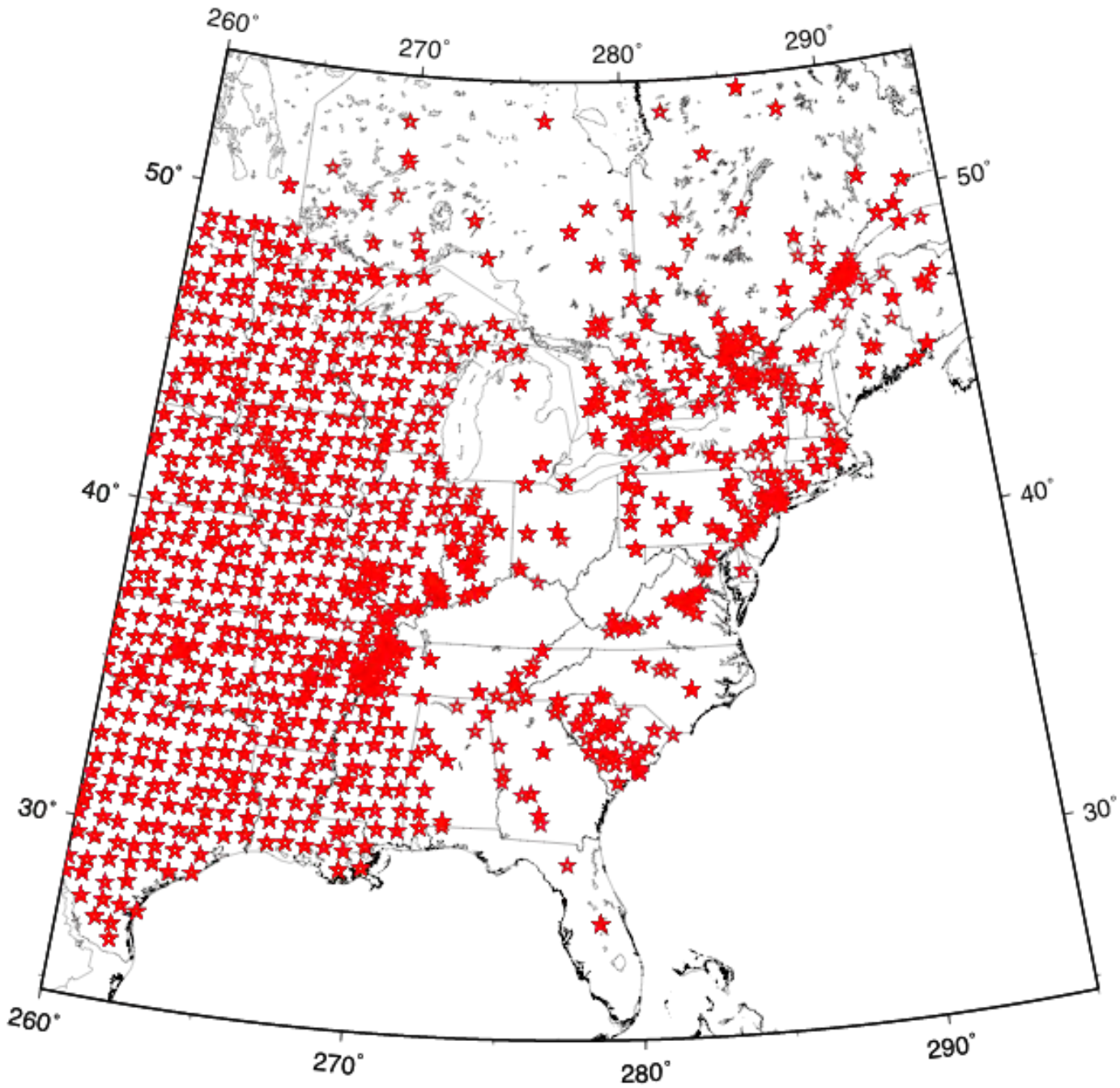
## M 6.0 Attenuation Relations at Different Site Soils



# NGA East Selected Earthquakes



# NGA East Recording Stations



# AB06+ Station Mean PGA Rock Residuals

