

Summary of the BCHydro GMPE for Subduction Earthquakes

N. Abrahamson

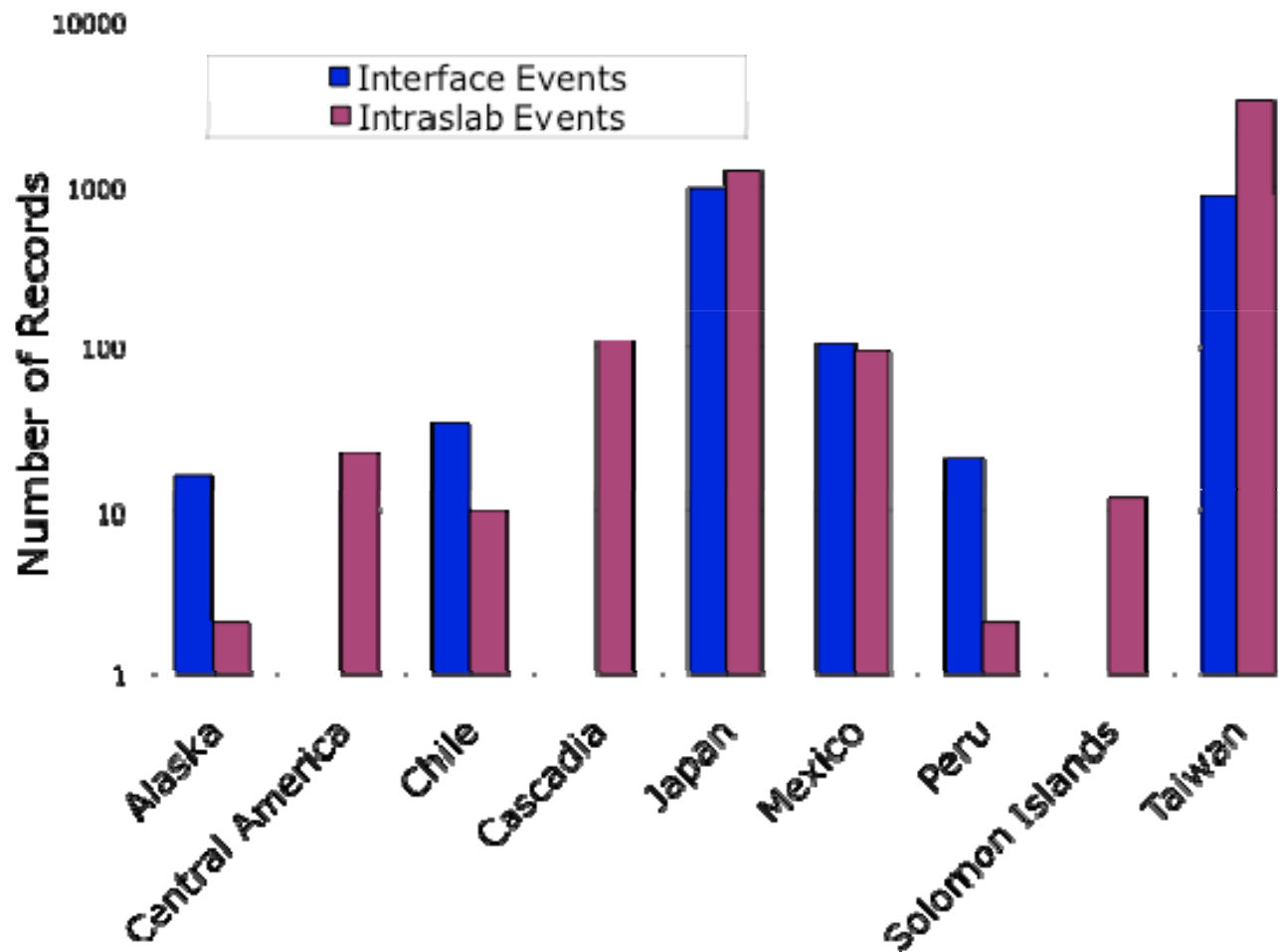
Mar 22, 2012

Data Set

- Combined available data through 2007
 - Youngs et al (1997) – global
 - Atkinson & Boore (2003) – global
 - Zhao et al (2006) – Japan
 - Lin and Lee (2008) – Taiwan
 - Macias & Atkinson (2009) – Central America
 - Other available data
 - About 6000 recordings from 292 earthquakes in full set
- 2010 Chile and 2011 Tohoku
 - Not included in data set, but model adjusted based on these data

Datasets

Global Region Distribution



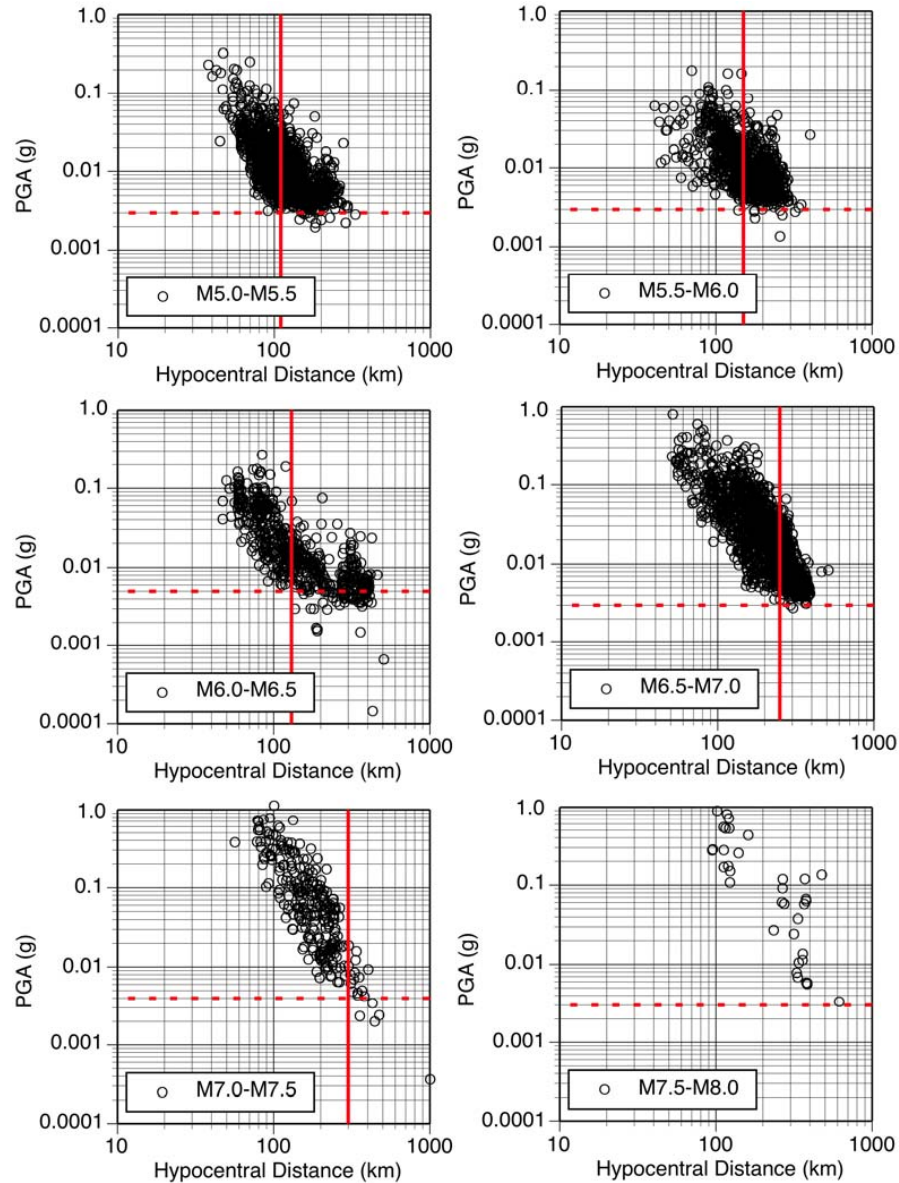
292 Earthquakes
(9946 record pairs)

163 Interface
(3557 record pairs)

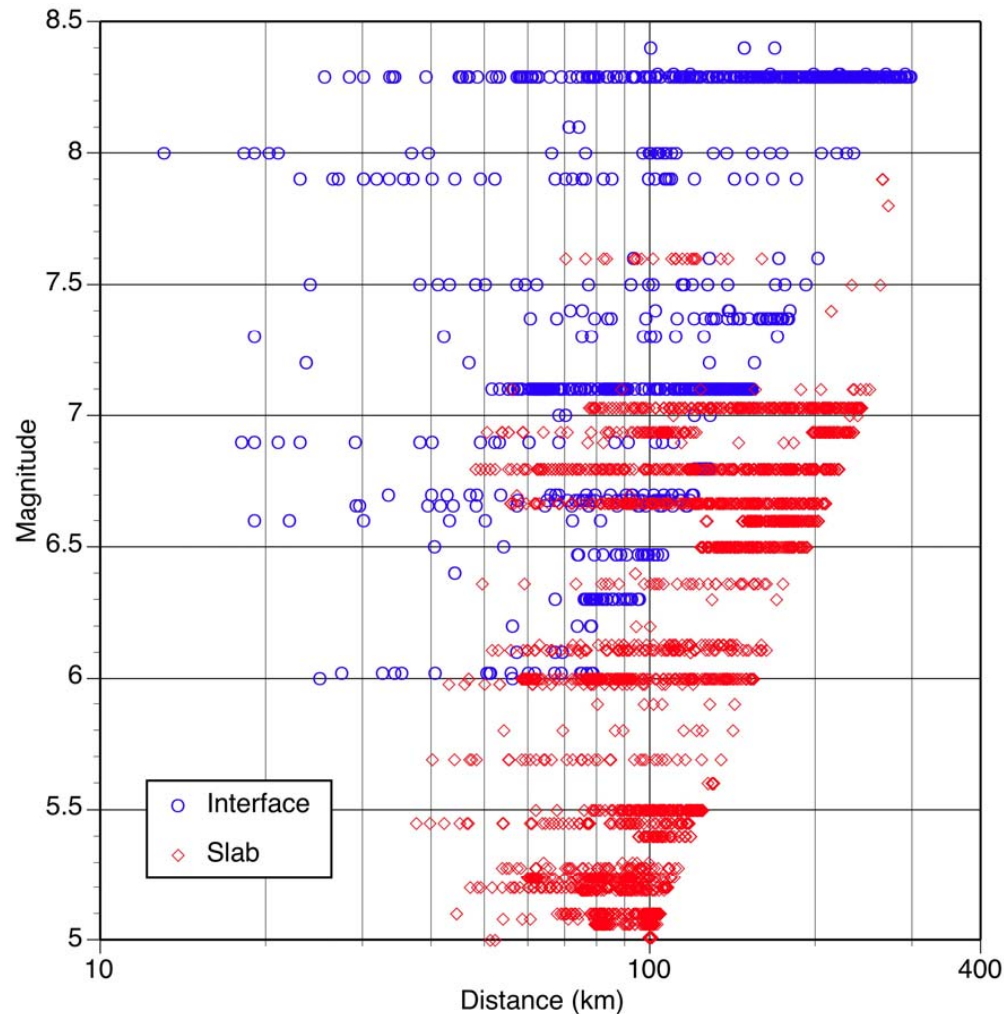
129 Intraslab
(6389 record pairs)

Slab Dataset

Issue: truncation of small amplitude data



Final Dataset



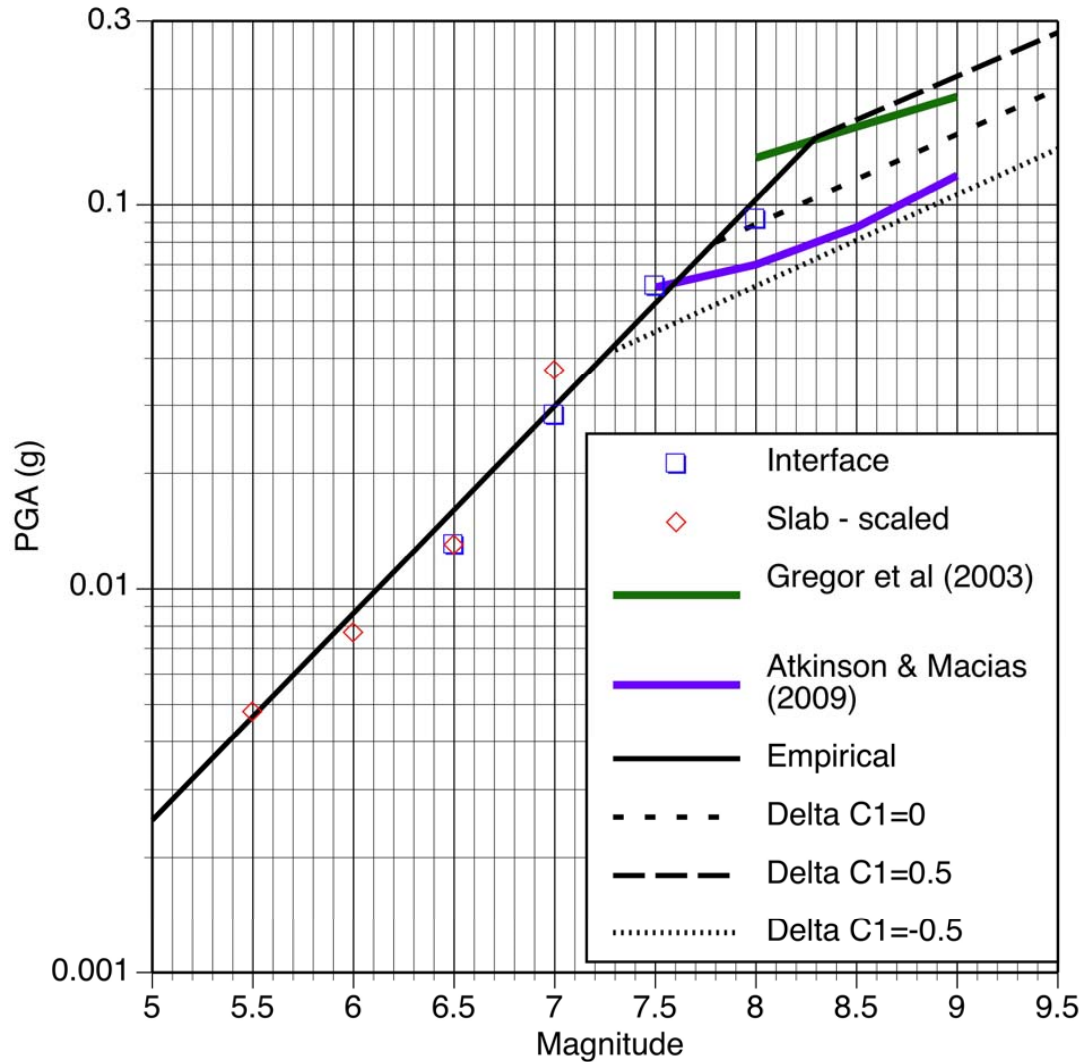
Slab:
63 earthquakes
2590 recordings

Interface:
43 earthquakes
960 recordings

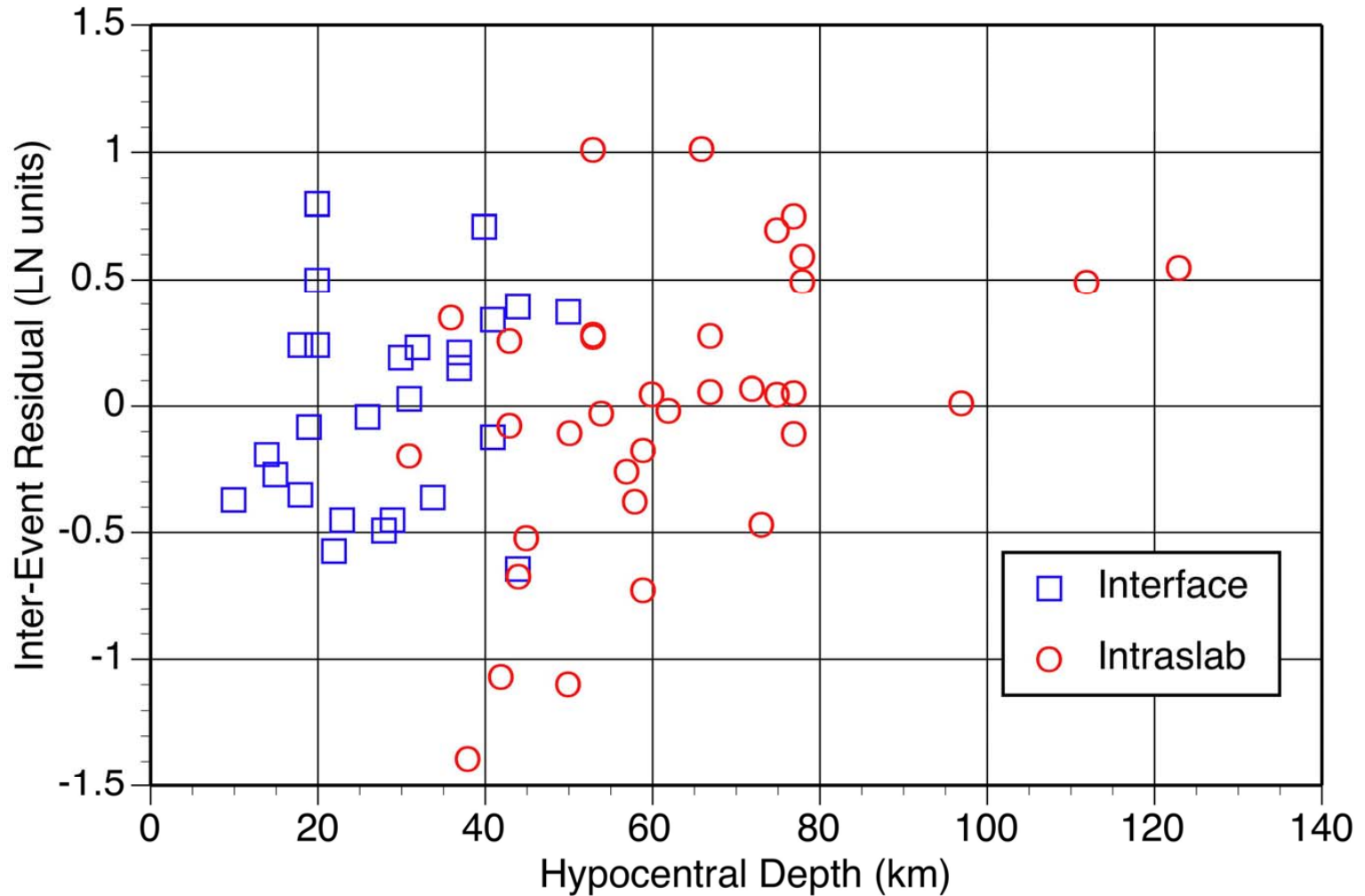
Model Features

- Magnitude Scaling
 - Includes break in magnitude scaling at large magnitudes (C1) based on simulations
 - Revised based on 2010 Chile and 2011 Tohoku
- Depth
 - Only applies to slab events
- Site
 - VS30 with non-linear site response based on AS08 and CB08 NGA models (PEN range curves)
- Forearc/backarc
 - Includes different rates of attenuation for forearc and backarc sites
- Sigma
 - Both traditional and single-station sigma
- Epistemic Uncertainty
 - Includes range of constants to capture range of constant terms from different regions

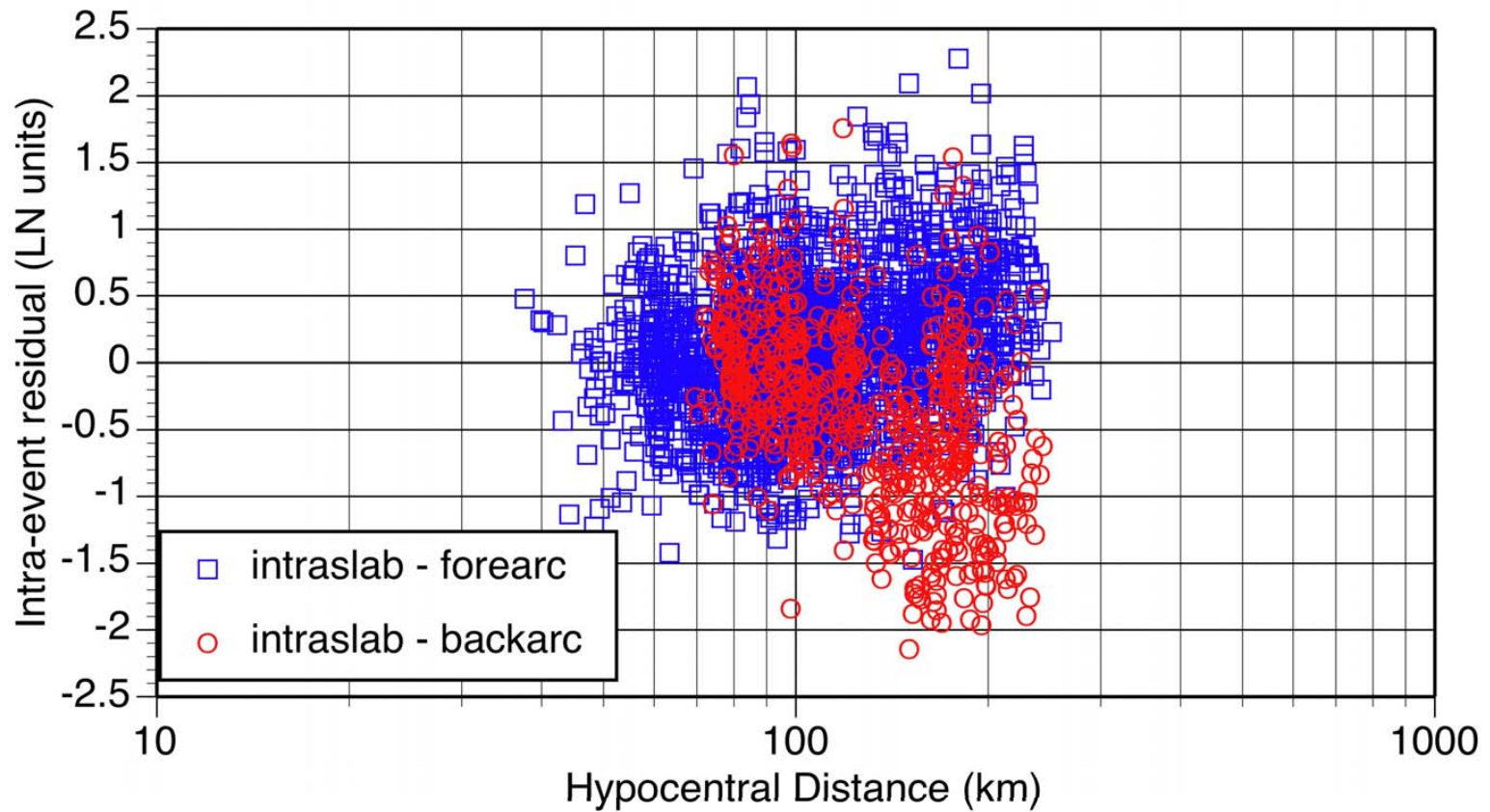
Magnitude Scaling (R=100 km)



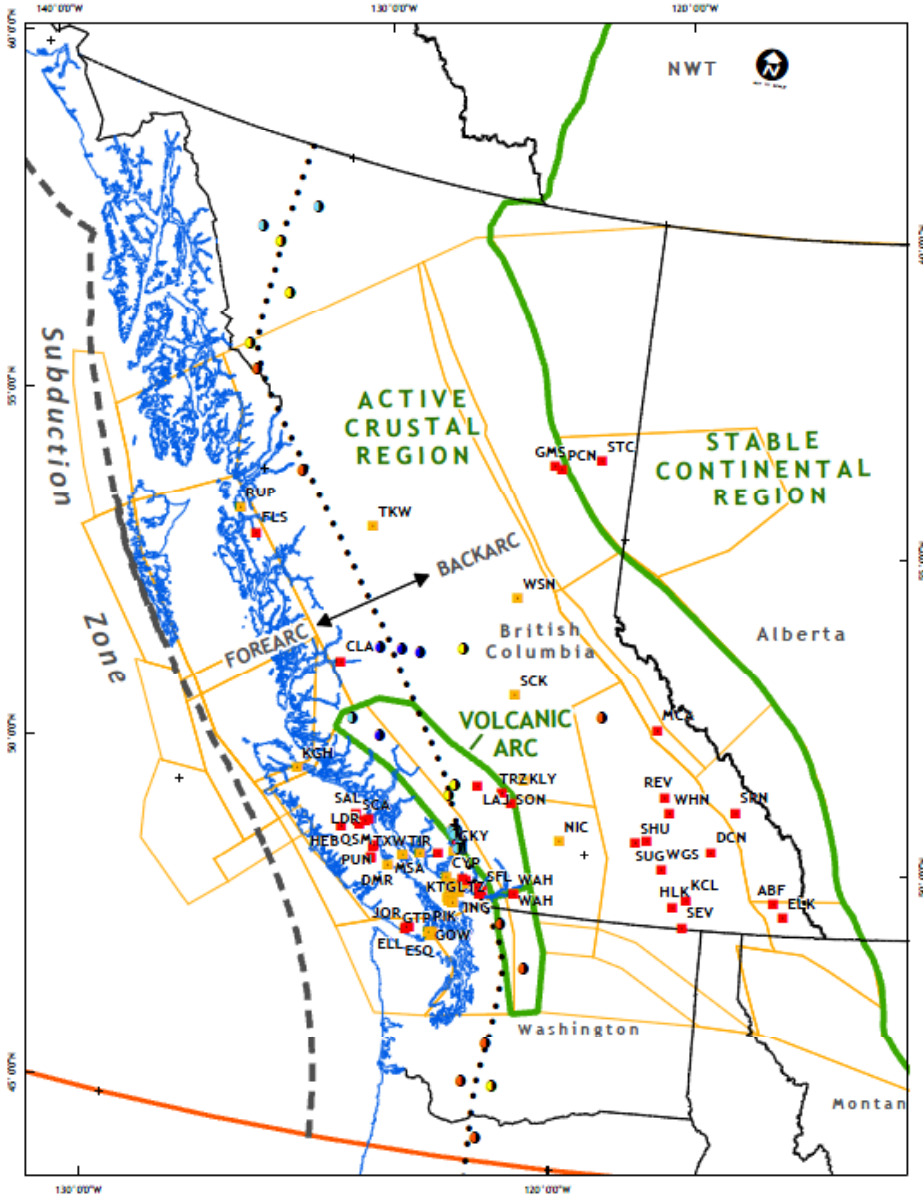
Hypocentral Depth Scaling




Forearc or Backarc?



Forearc or Backarc?



- Legend**
- Cascade Volcanoes
 - Activity (BSO)
 - < 100 years ago
 - 1,000-10,000 years
 - 10,000-100,000 years
 - > 100,000 years
 - BC Hydro Data
 - BC Hydro Substrate
 - Active Alignment
 - Political Boundaries
 - District
 - Admin Boundary
 - Fault Zone
 - GMM_Zones_J
 - Volcanic Arc Region
 - BCI Area of Interest
 - Source Zone Geometry

BC Hydro 
Cascadia Volcanic Trend
Active, Stable and Volcanic Arc Regions

0 60 120 240 360 480
Kilometers

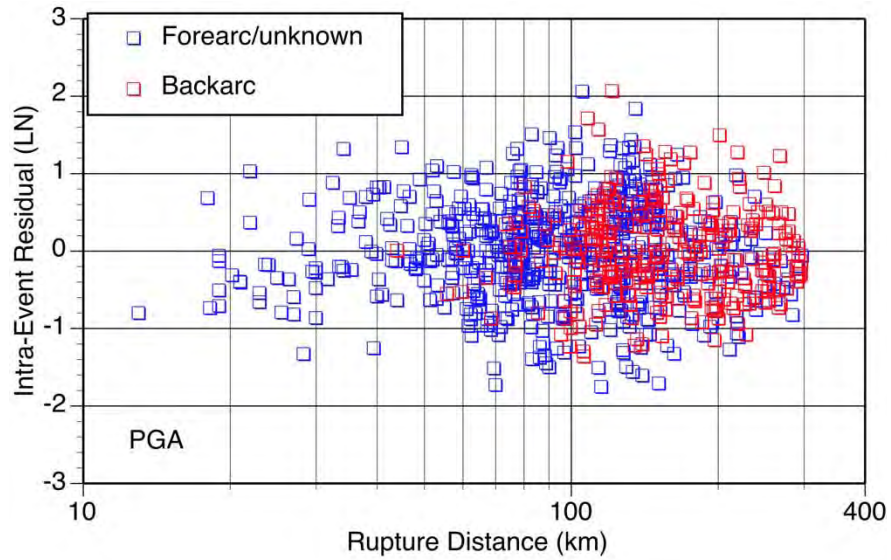
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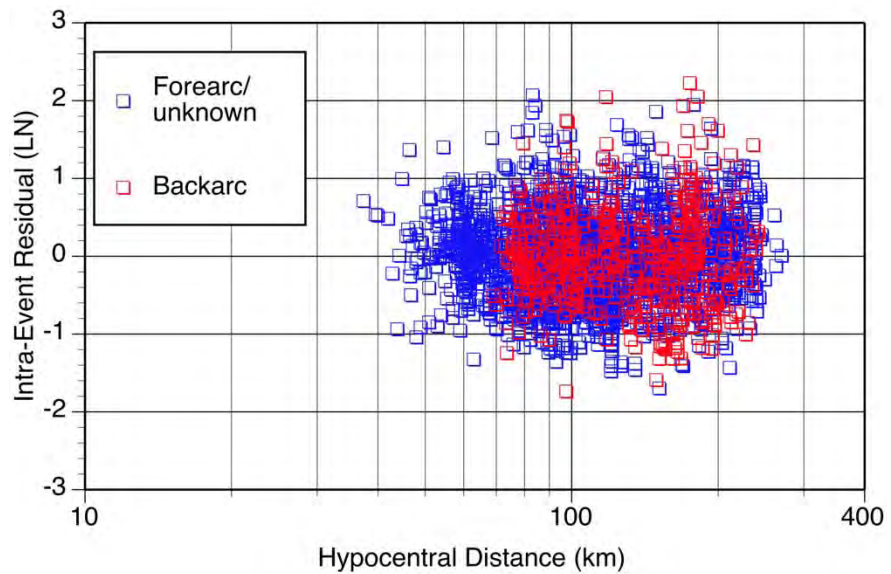
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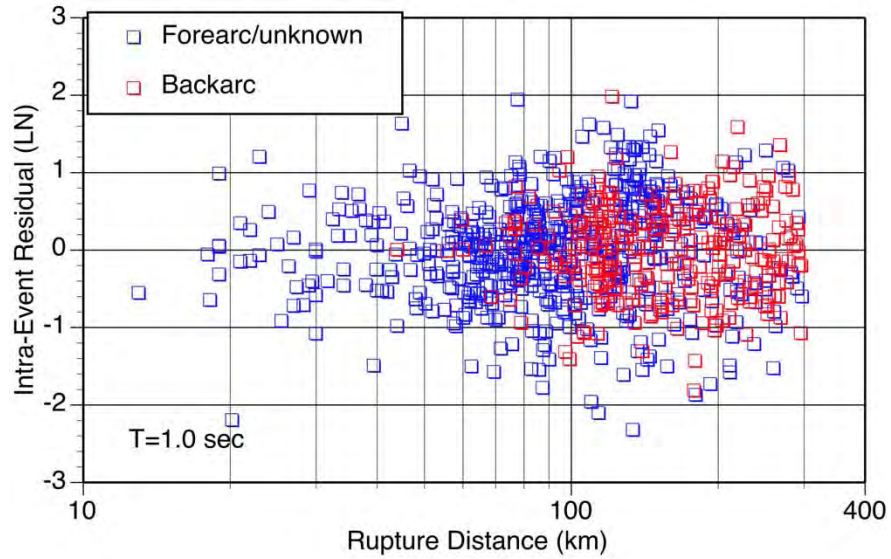
Interface



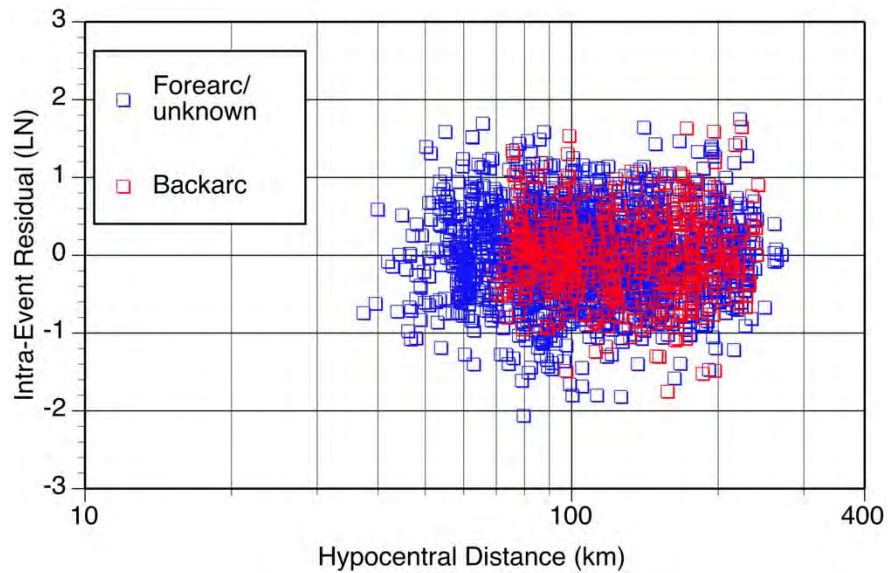
Slab



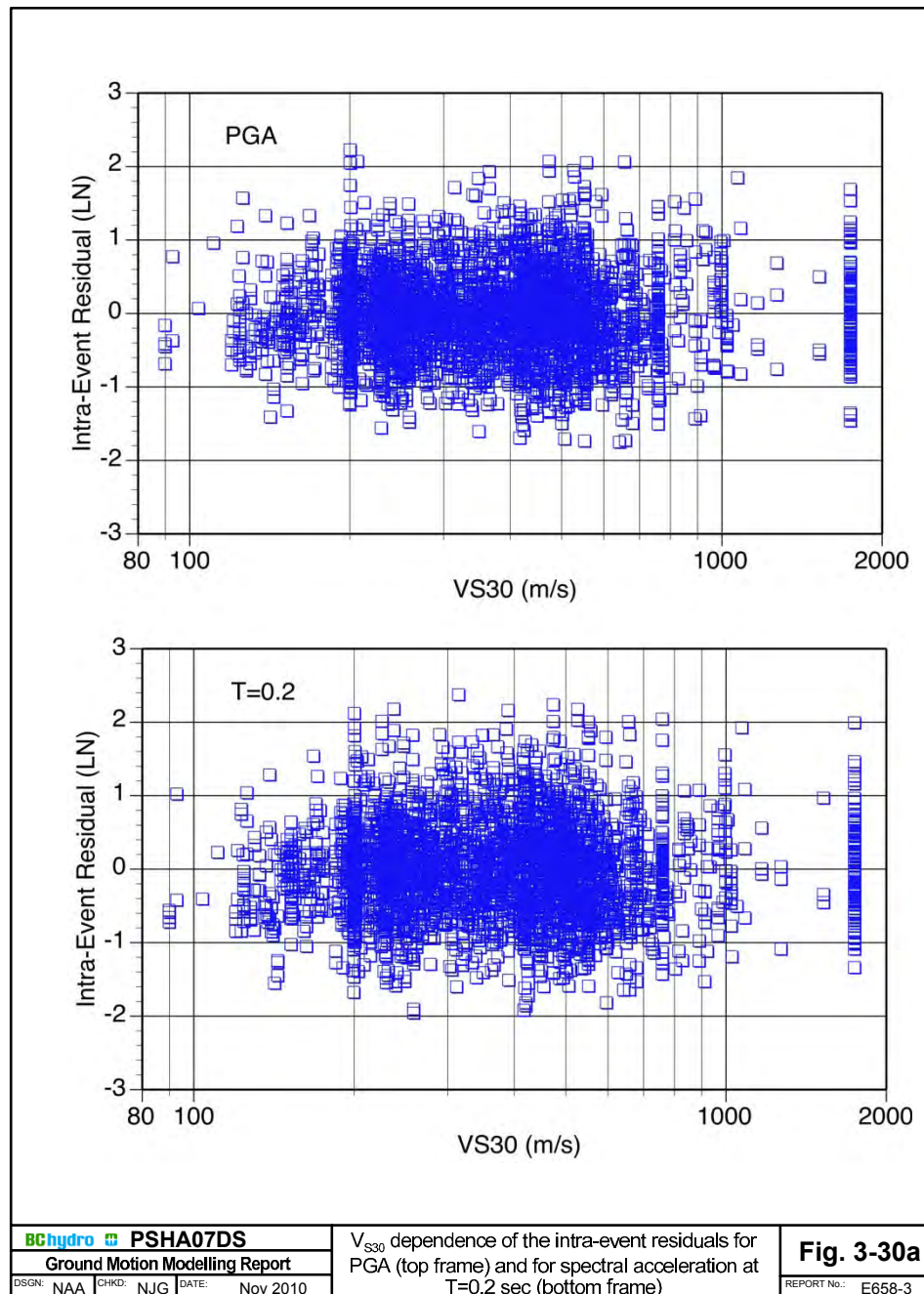
Interface

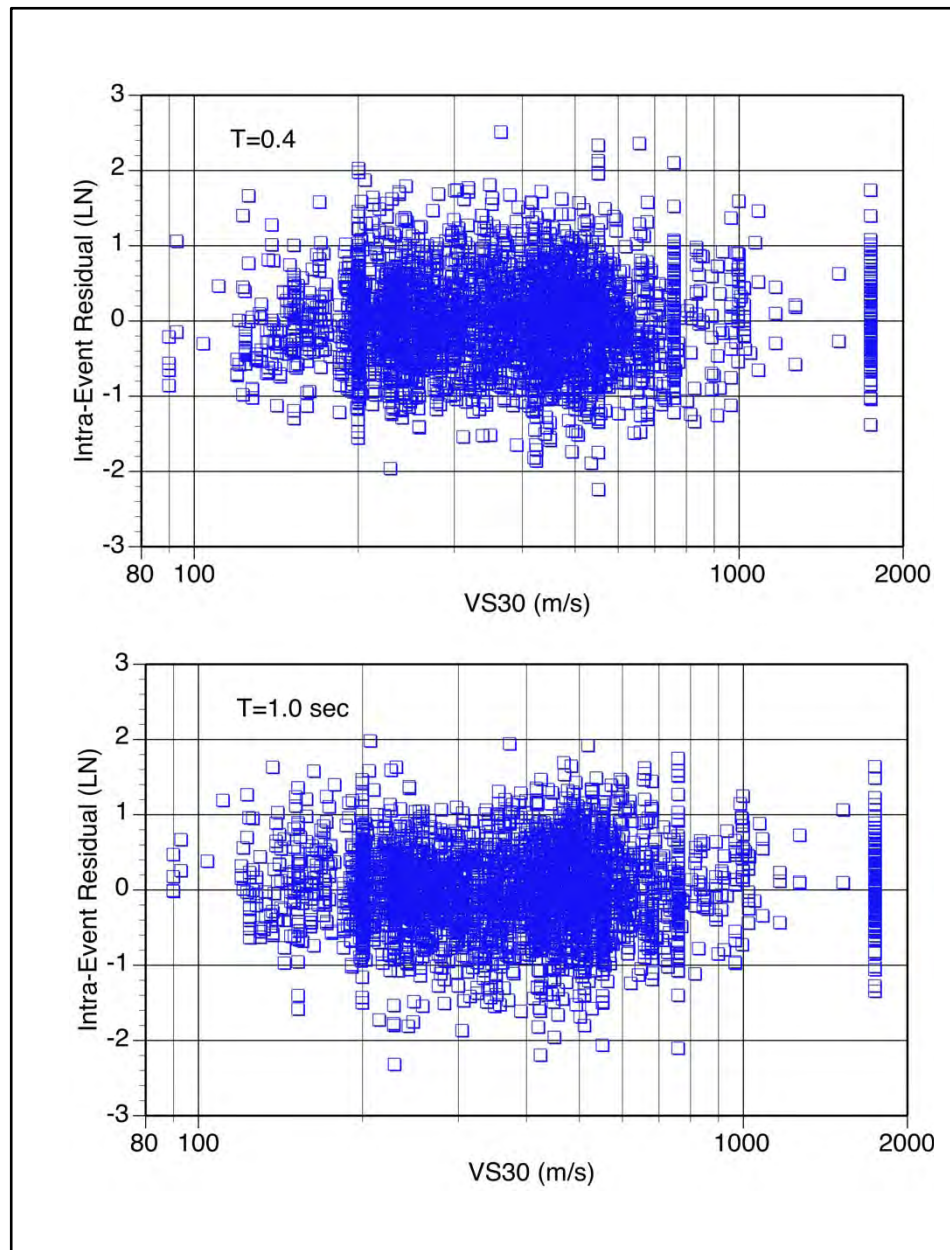



Slab

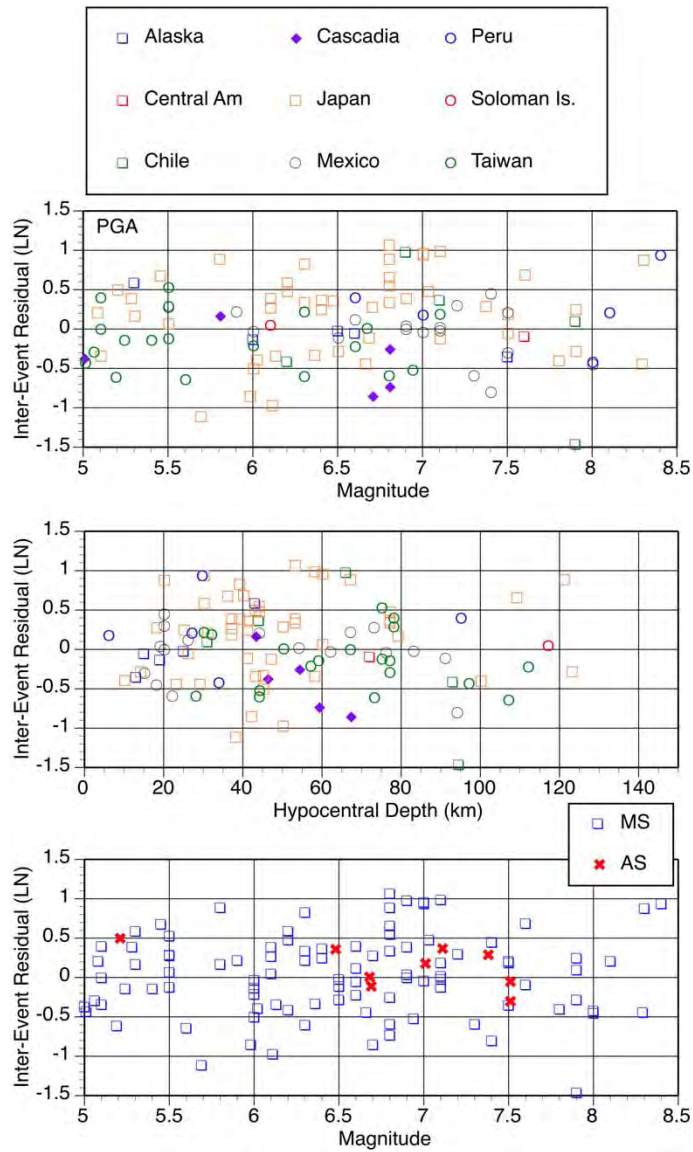


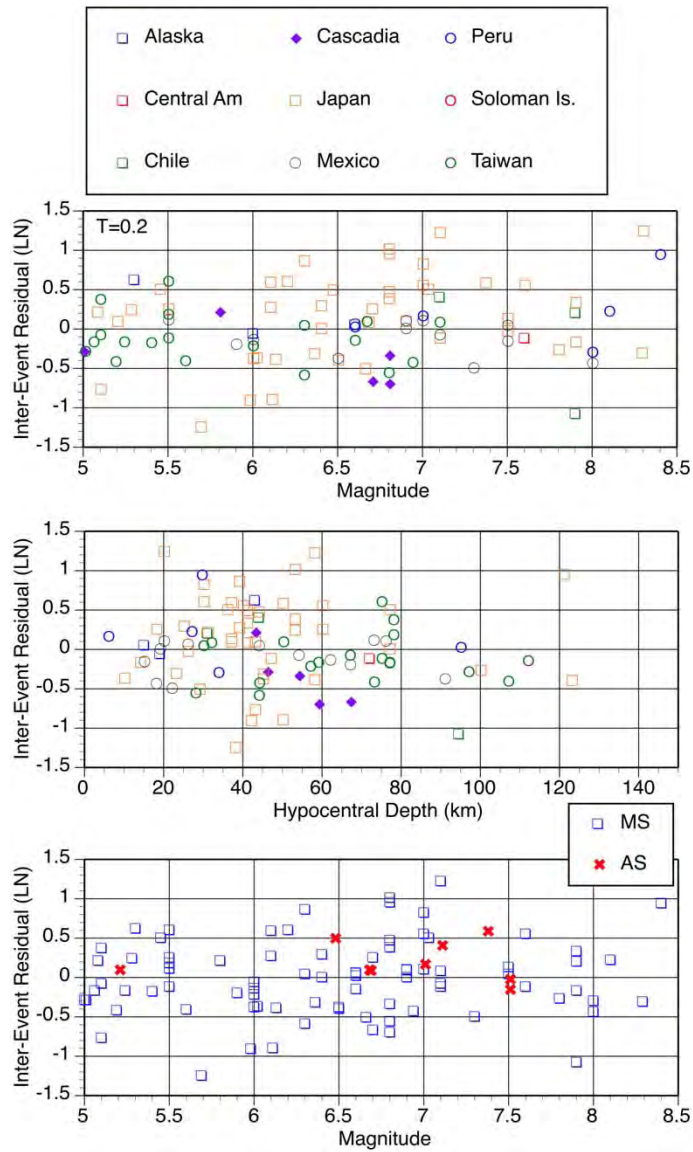
VS30

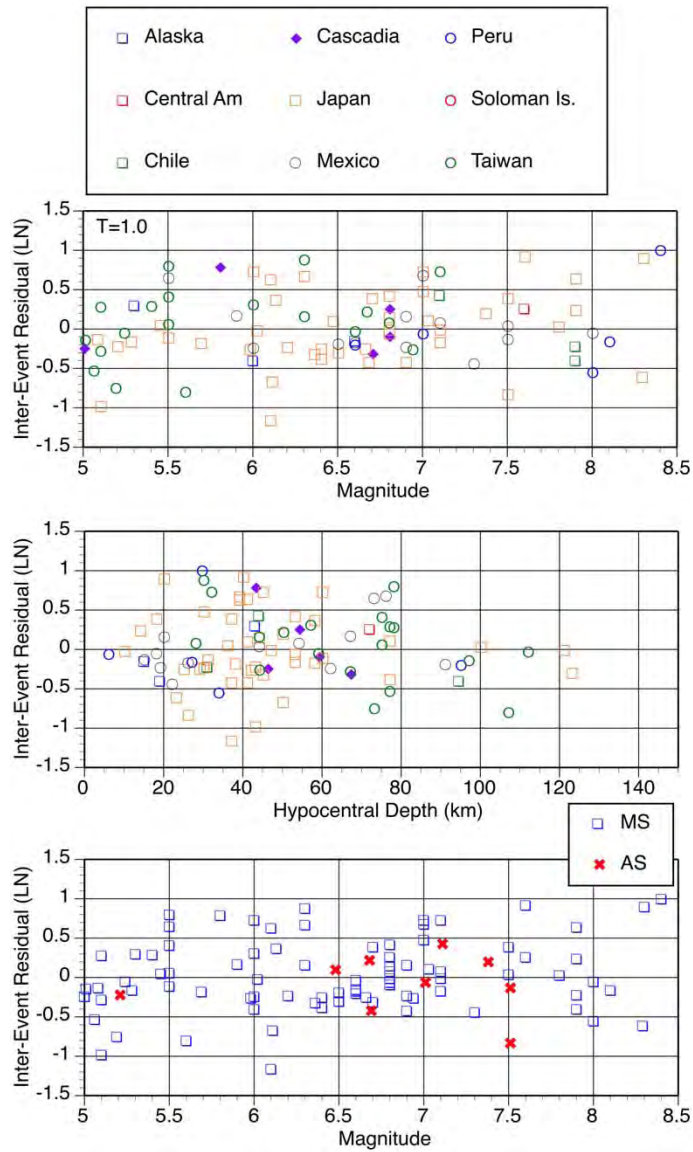


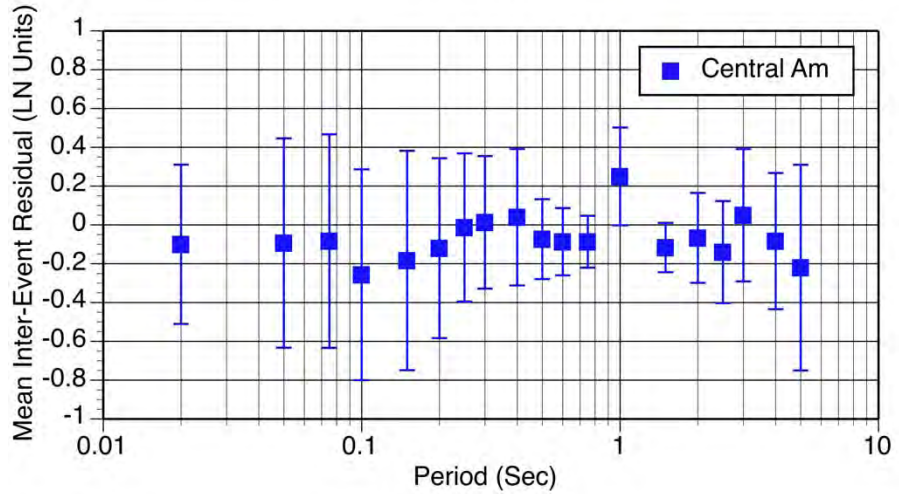
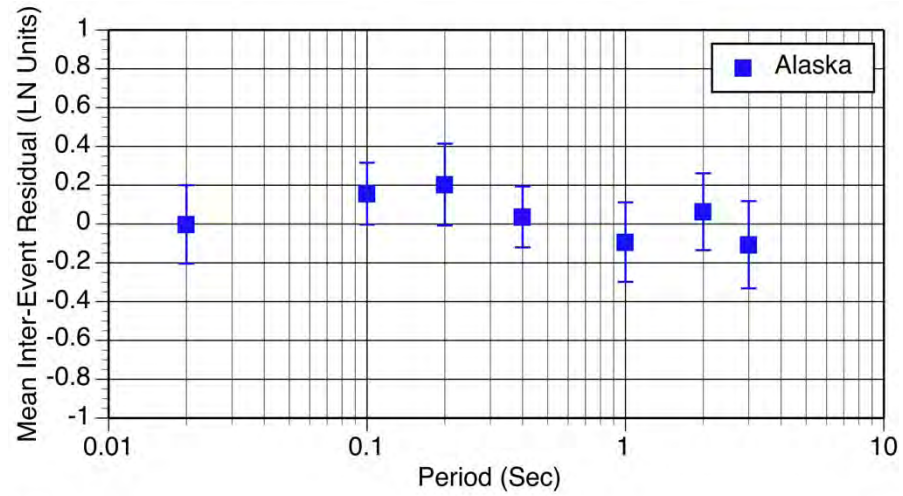


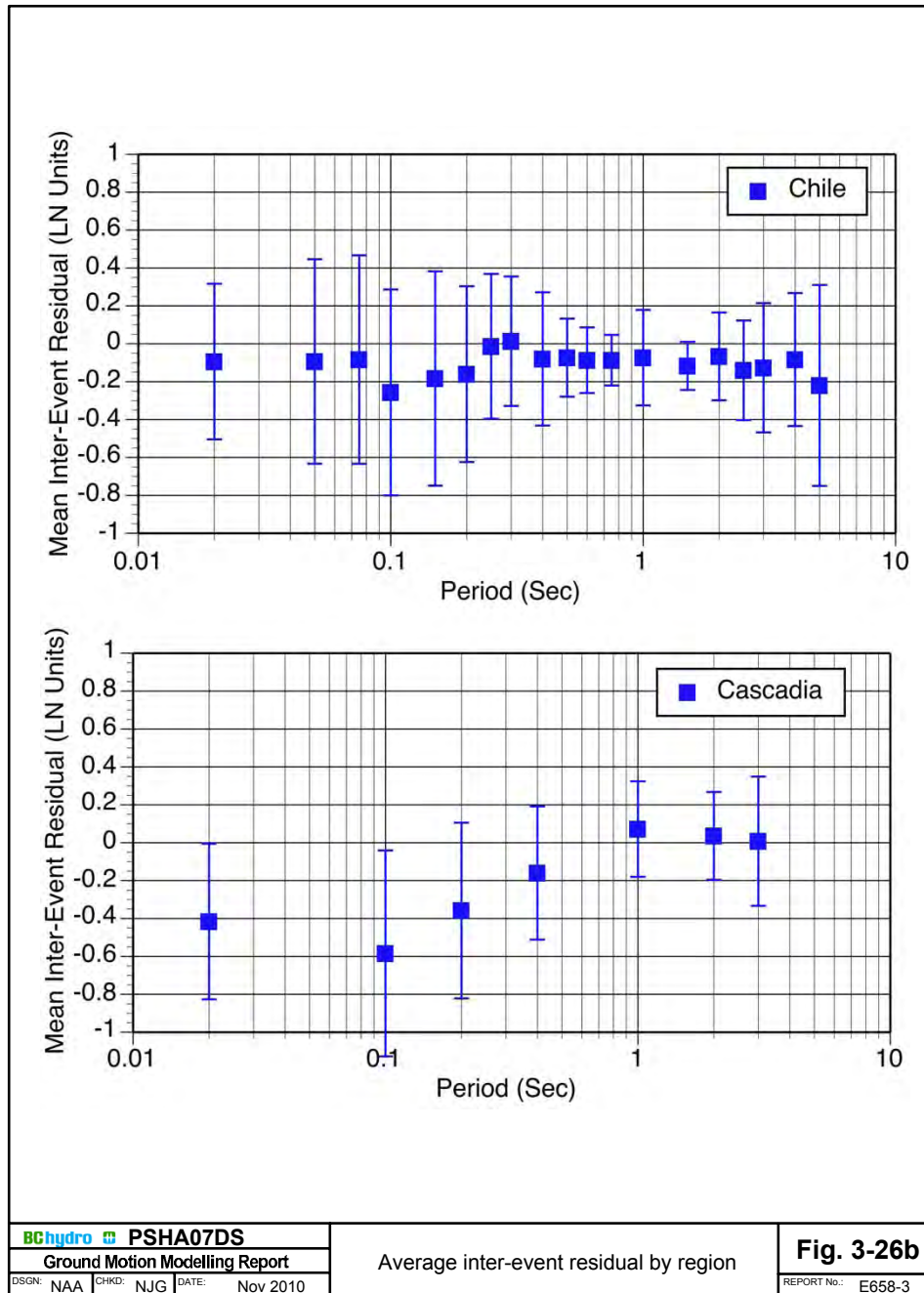
| | | | | |
|---|--------------------------|-------------------------------|---|---|
| BCHydro  PSHA07DS Ground Motion Modelling Report | | | V_{S30} dependence of the intra-event residuals for spectral acceleration at T=0.4 sec (top frame) and T=1.0 sec (bottom frame) | Fig. 3-30b REPORT No.: E658-3 |
| <small>DSGN:</small> NAA | <small>CHKD:</small> NJG | <small>DATE:</small> Nov 2010 | | |

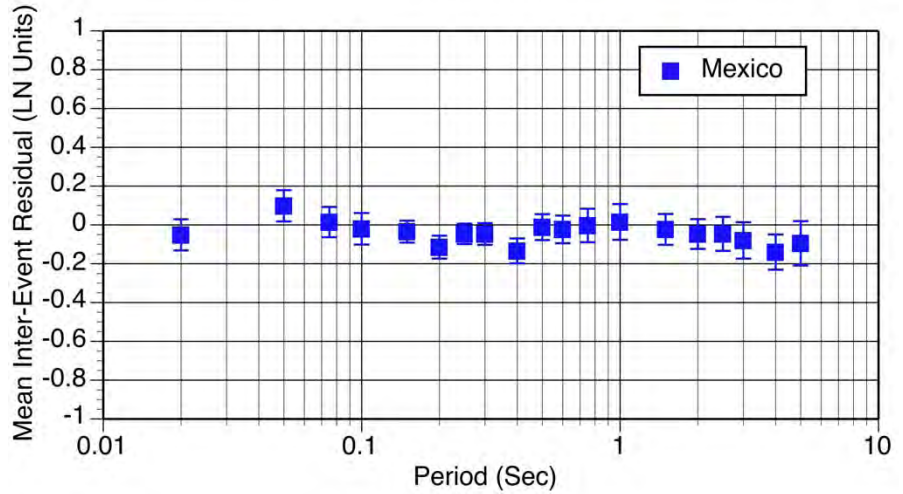
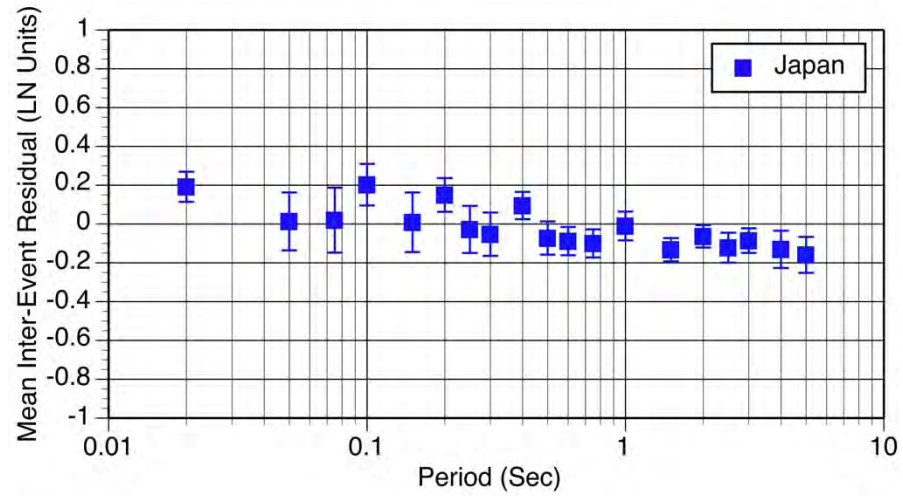


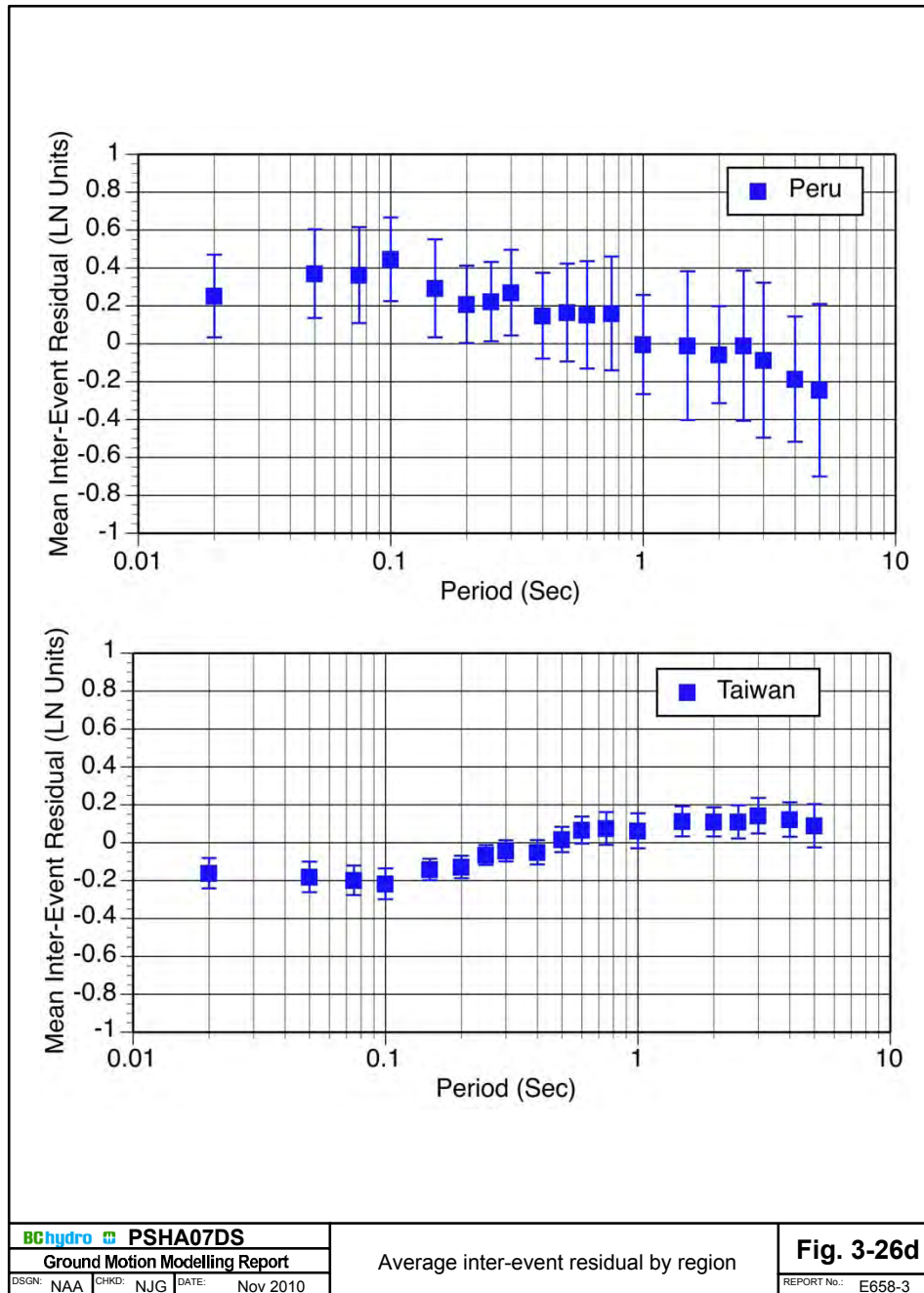




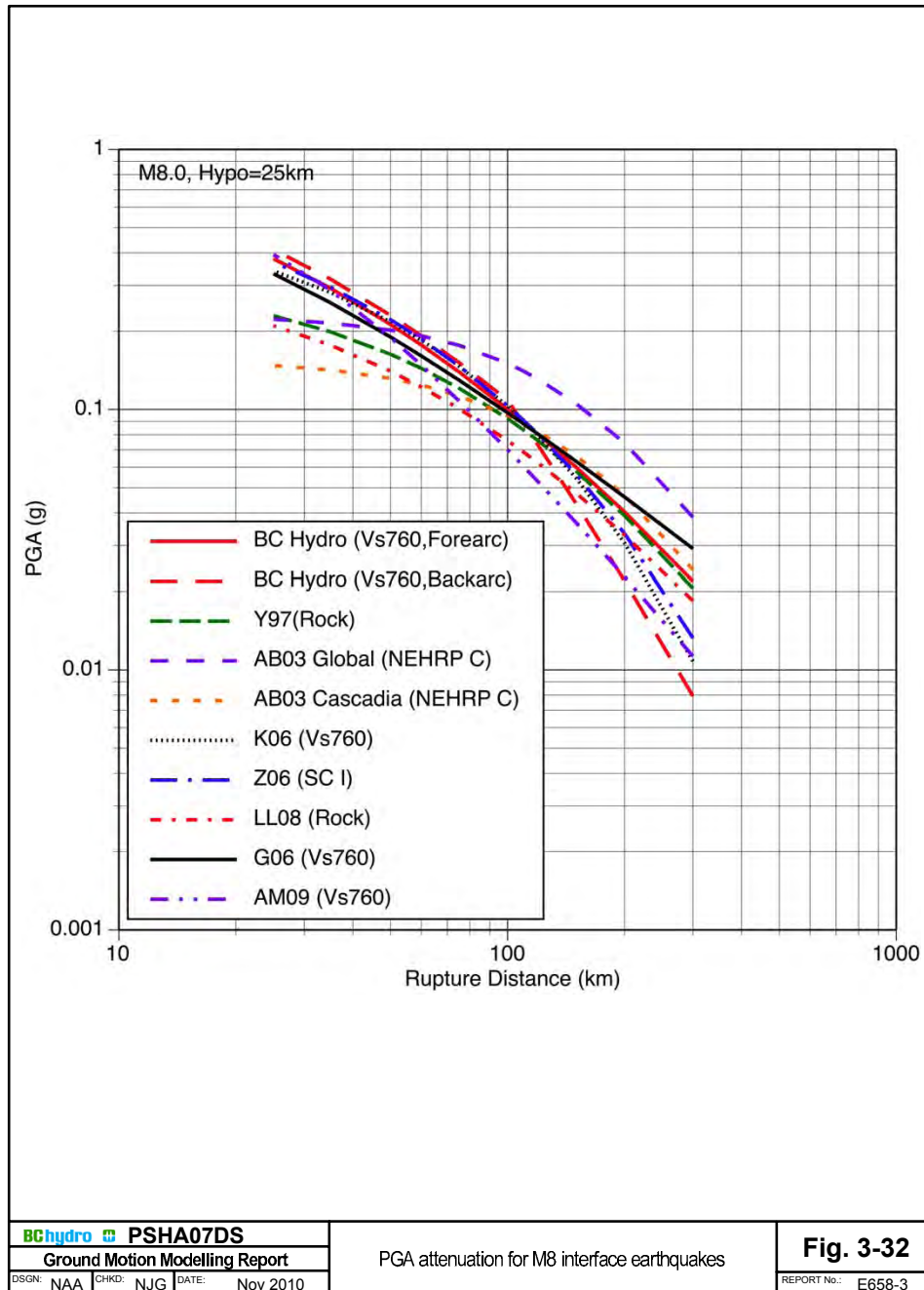




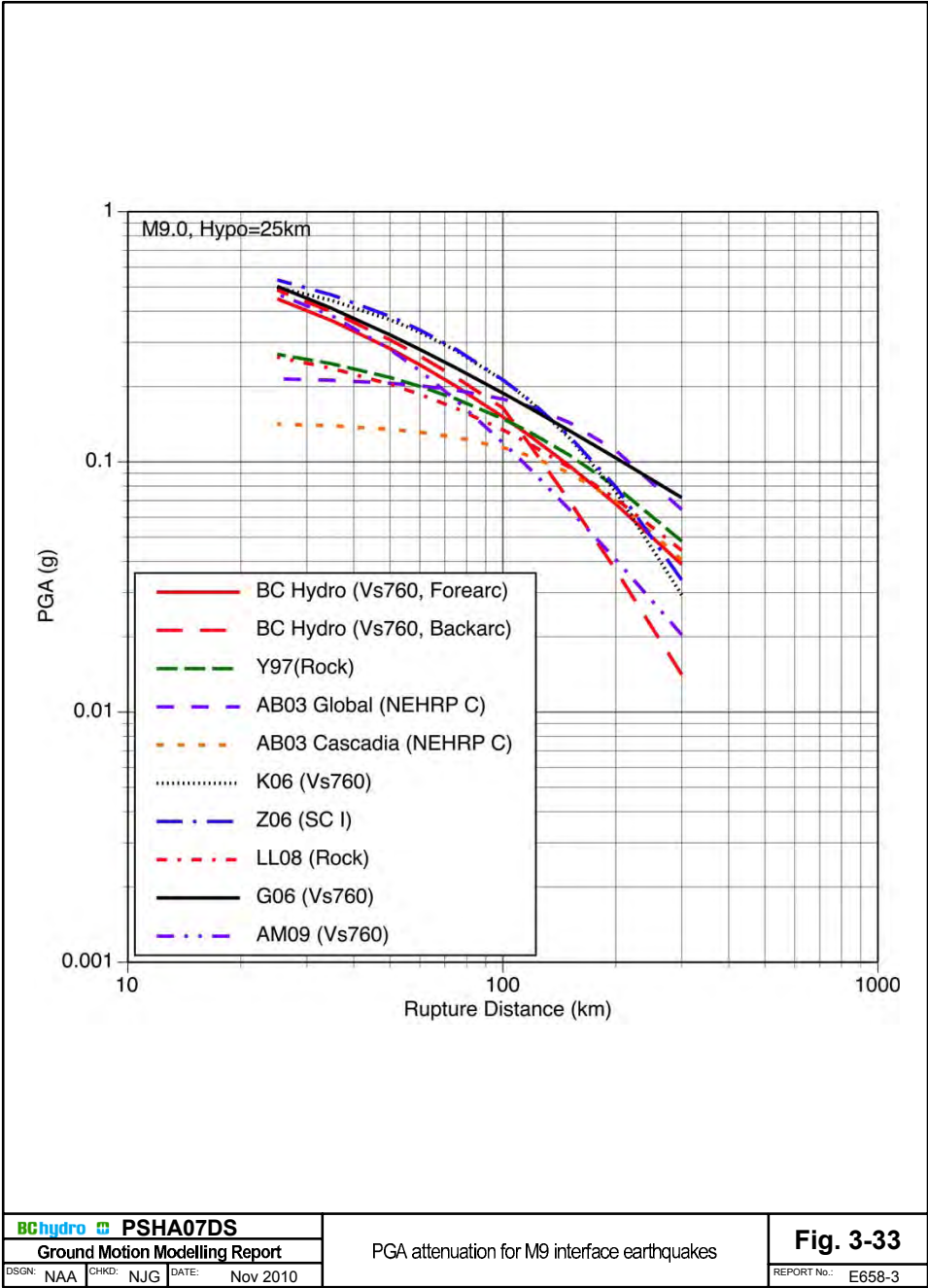




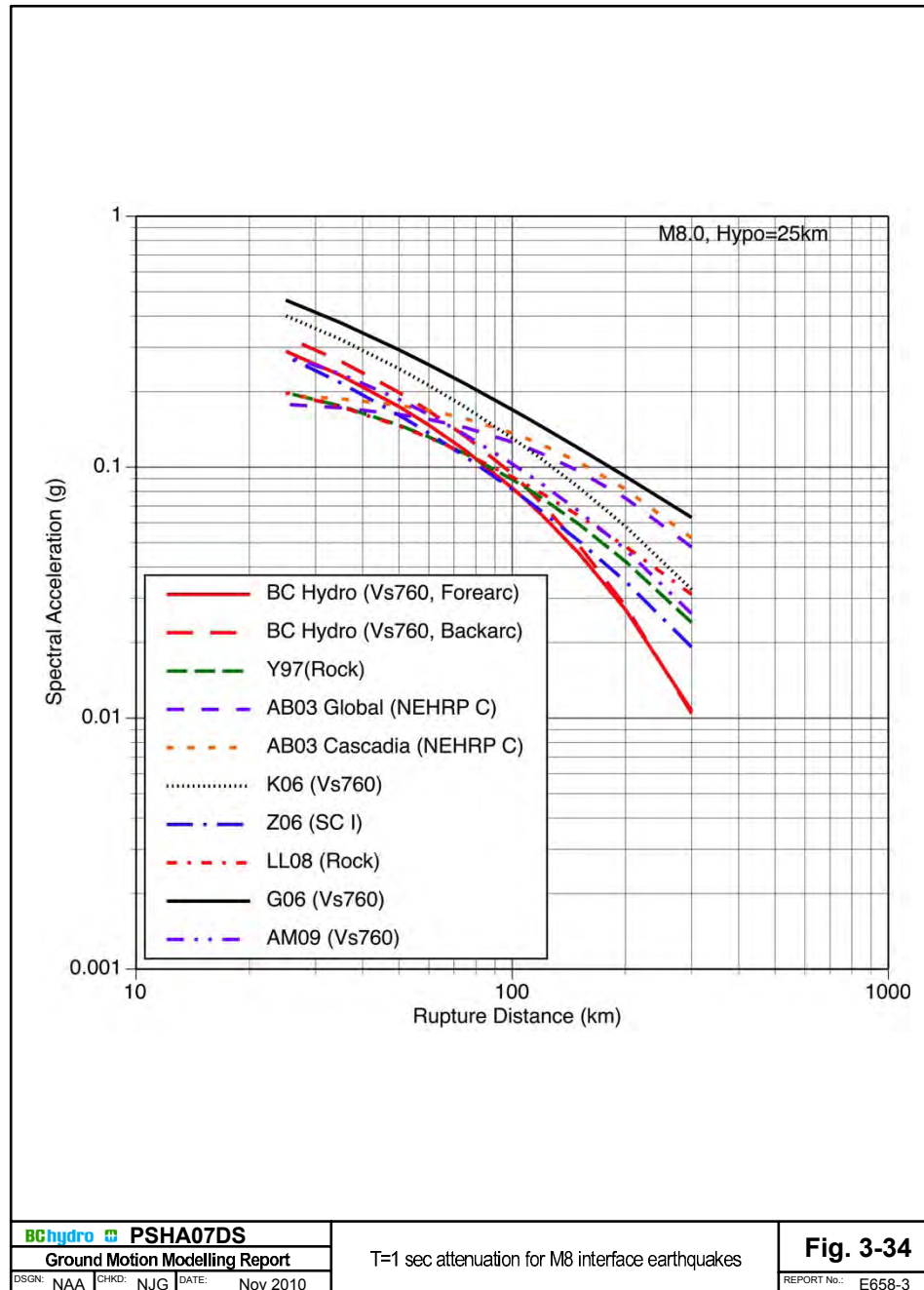
Interface M=8



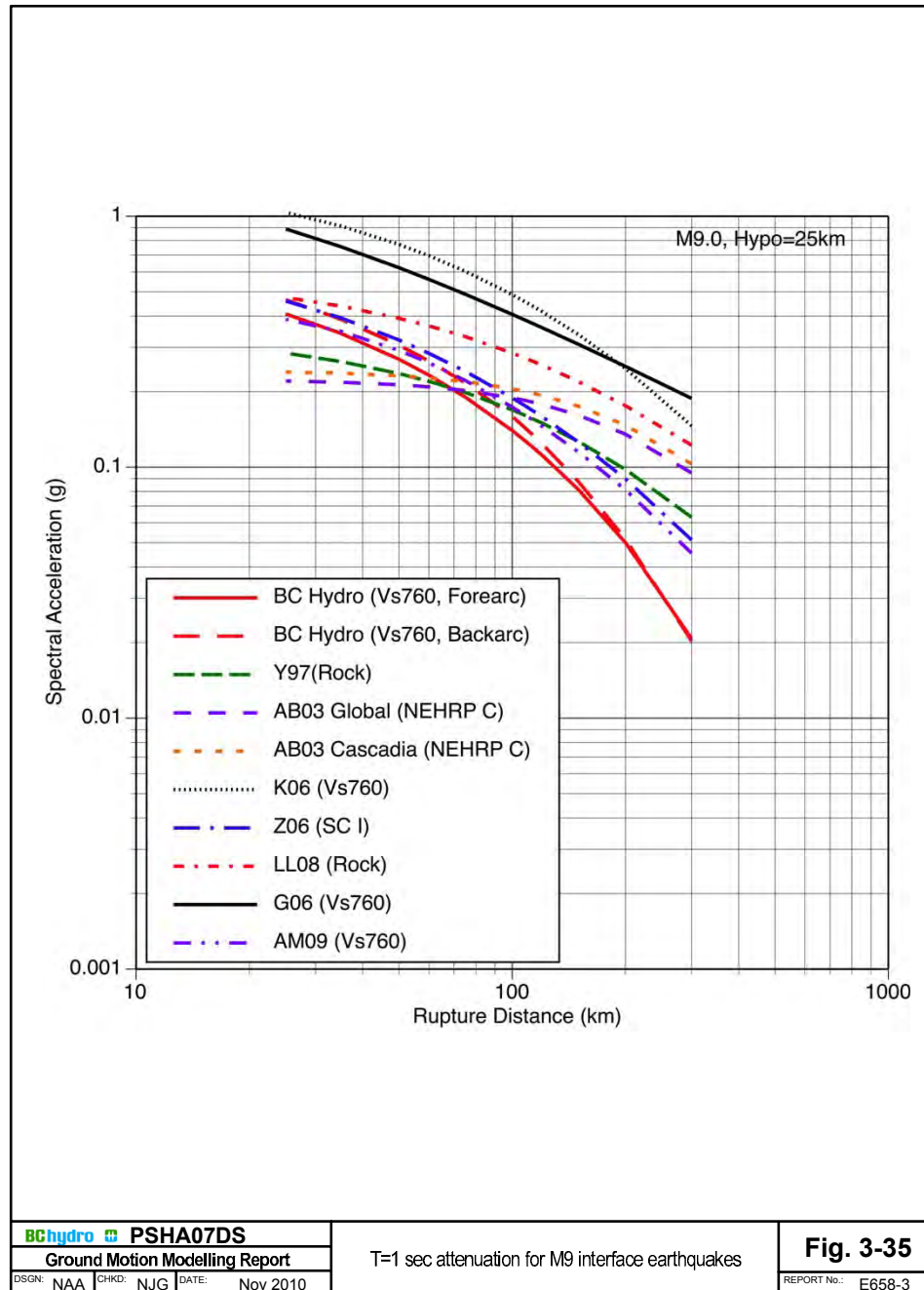
Interface M=9

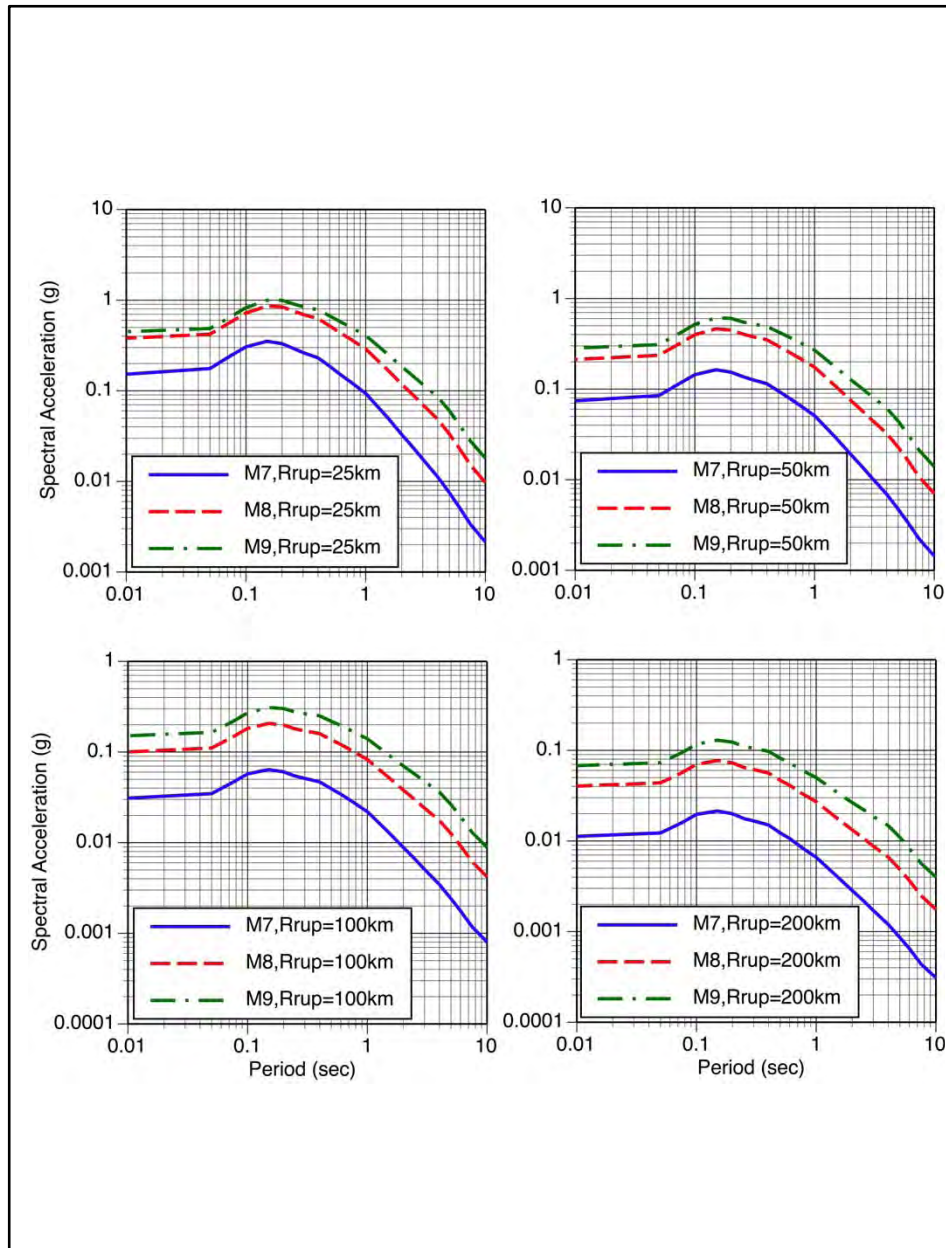


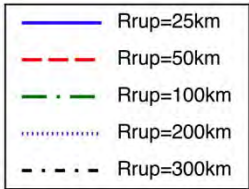
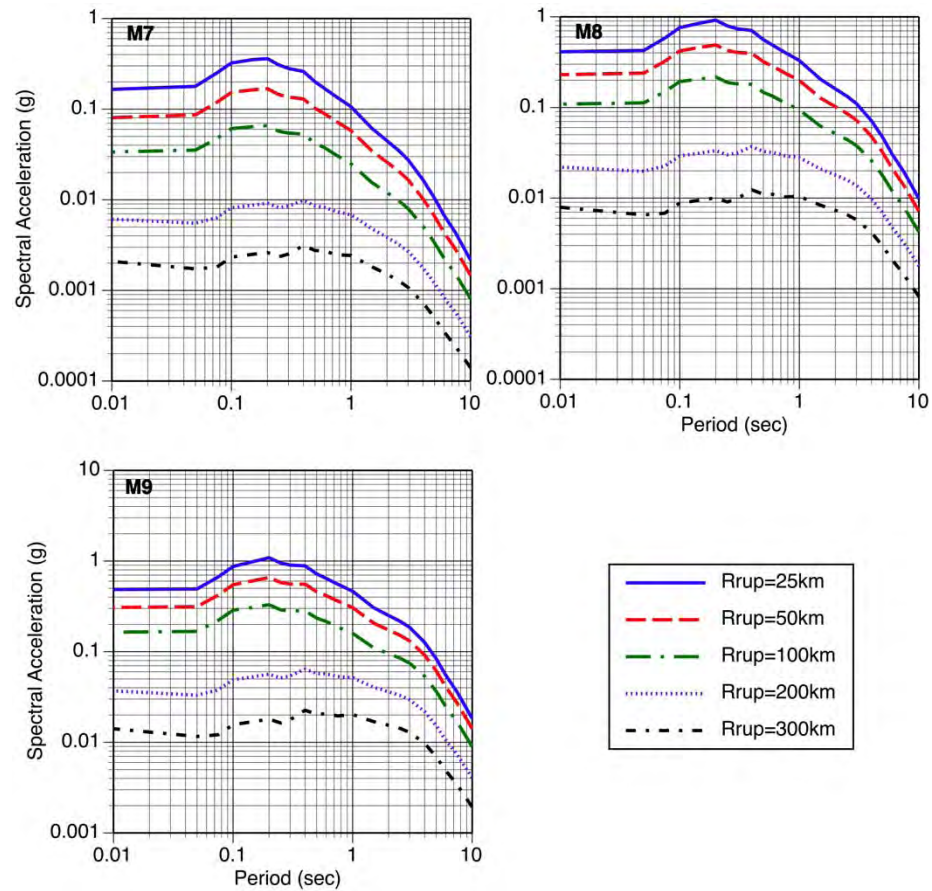
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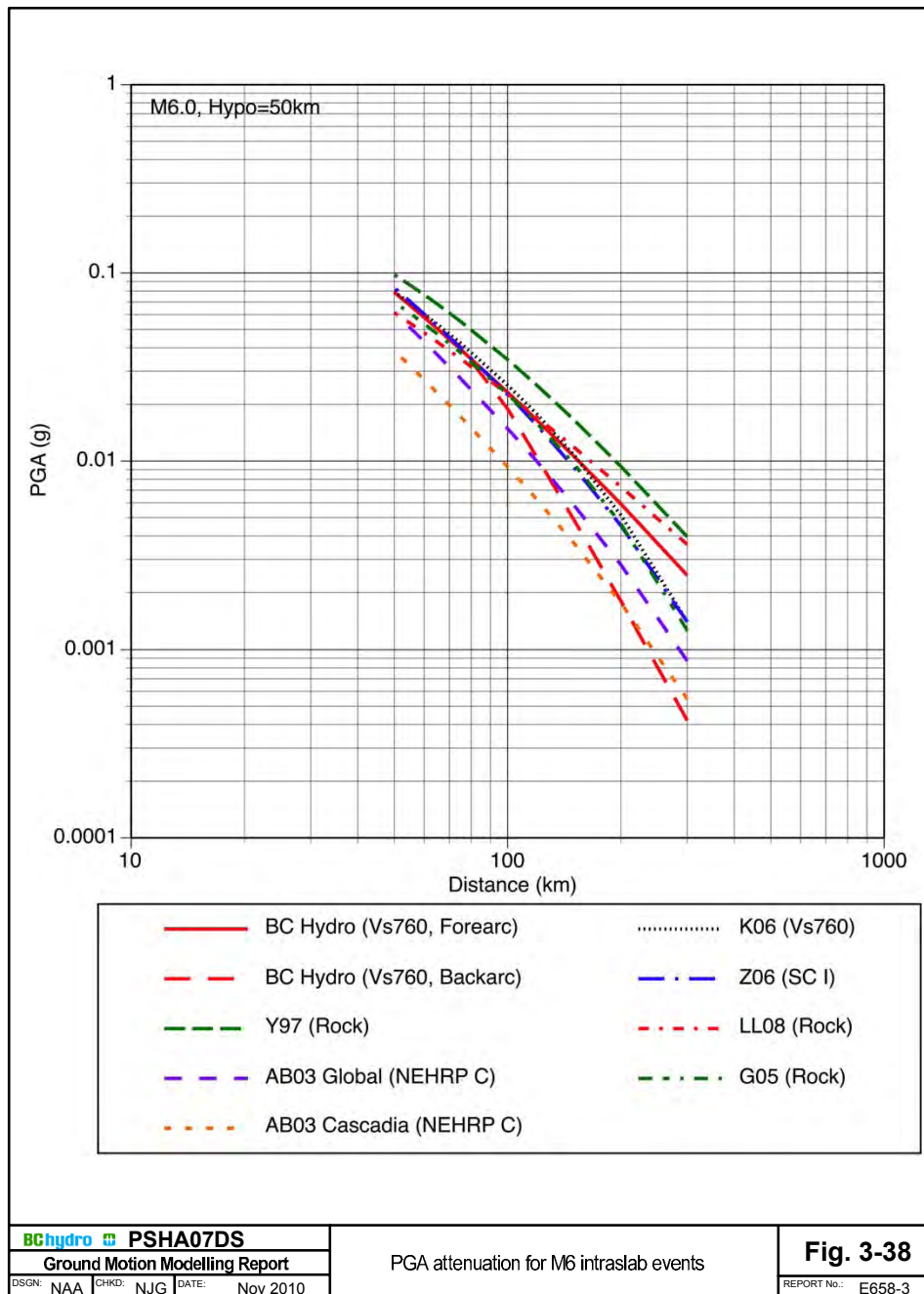


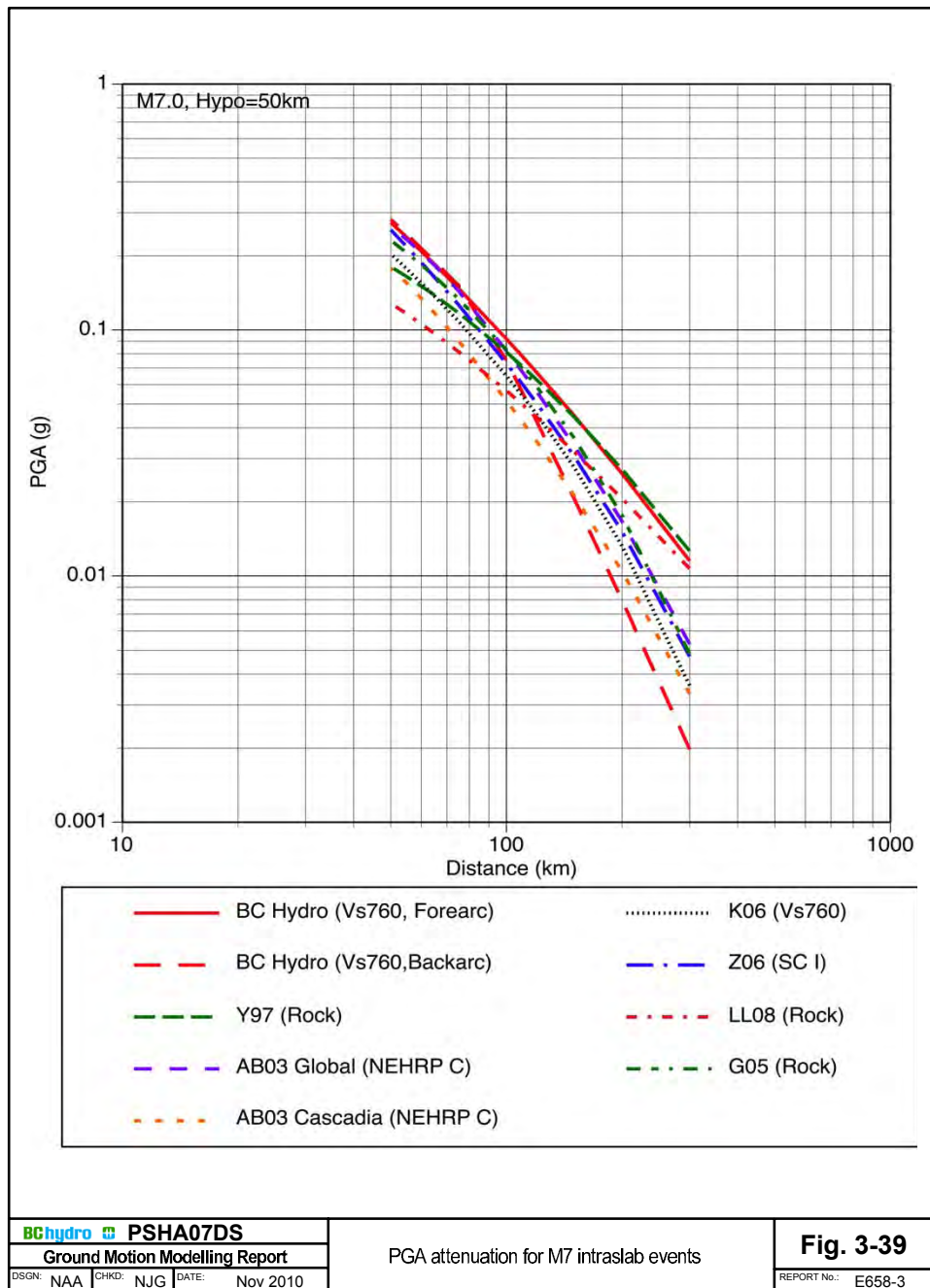
Interface M=9

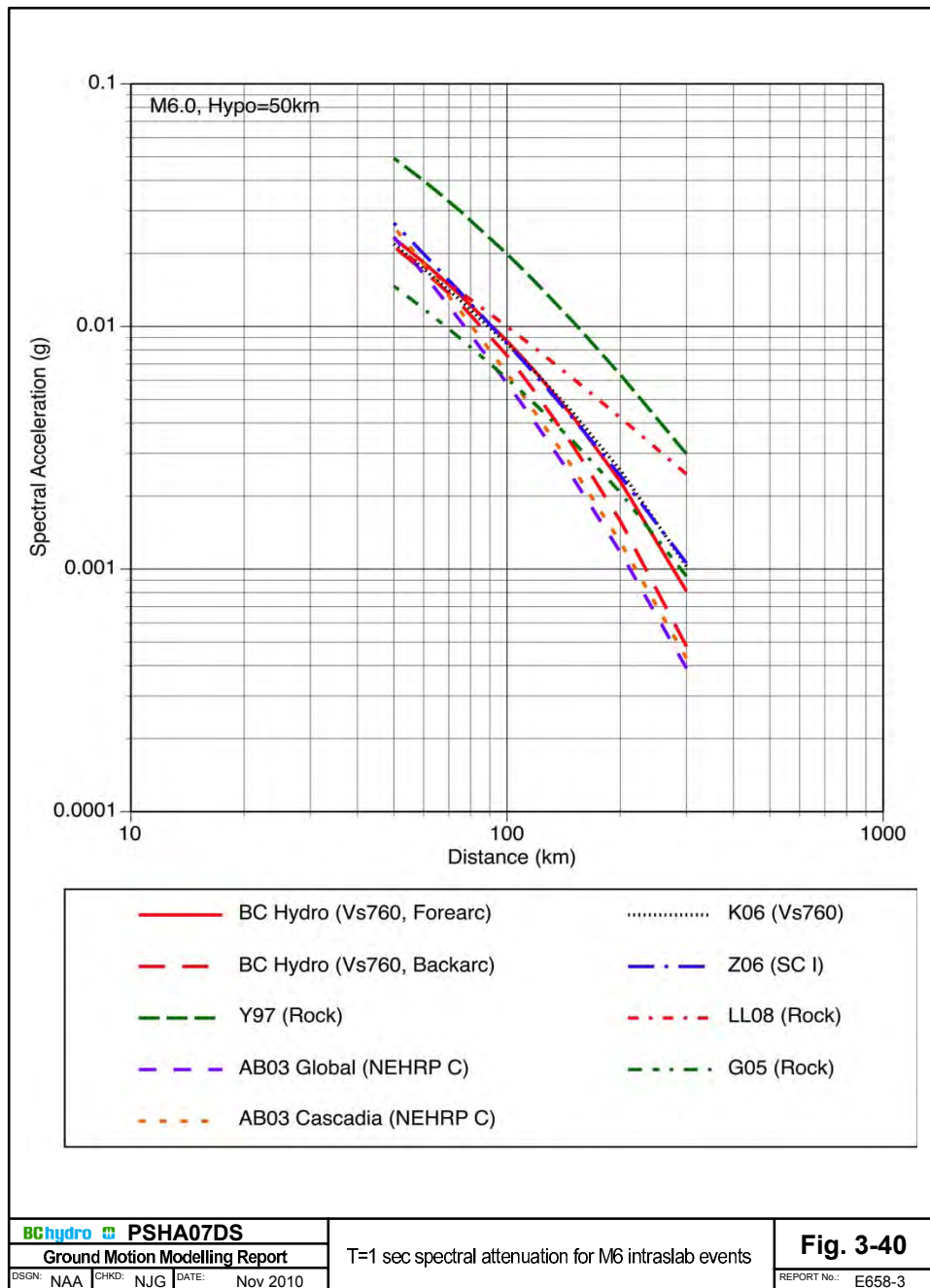


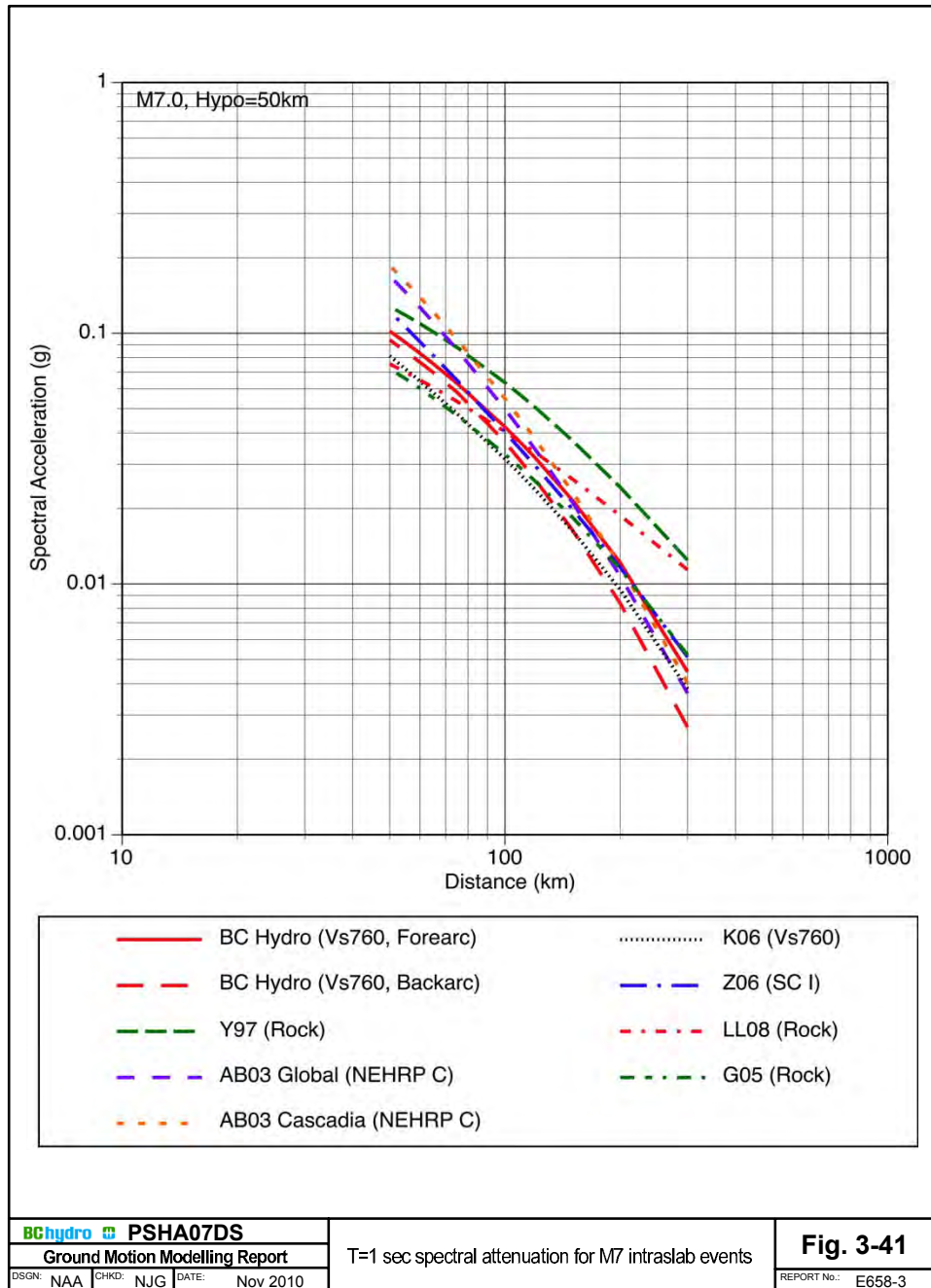


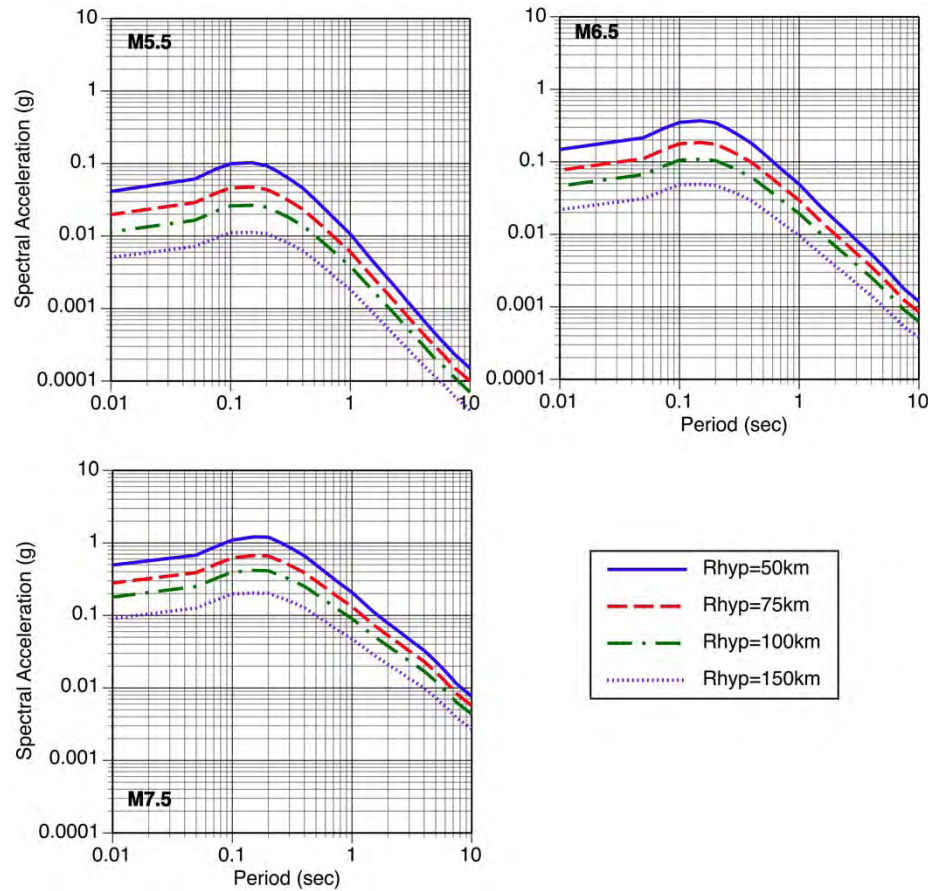


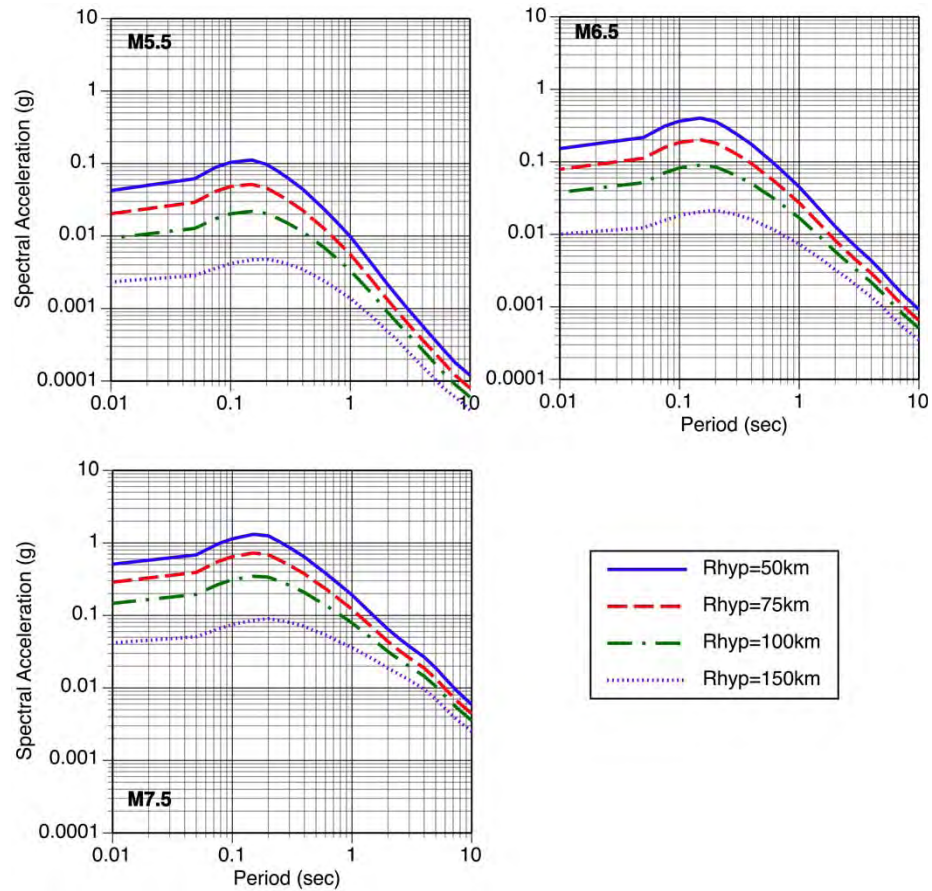


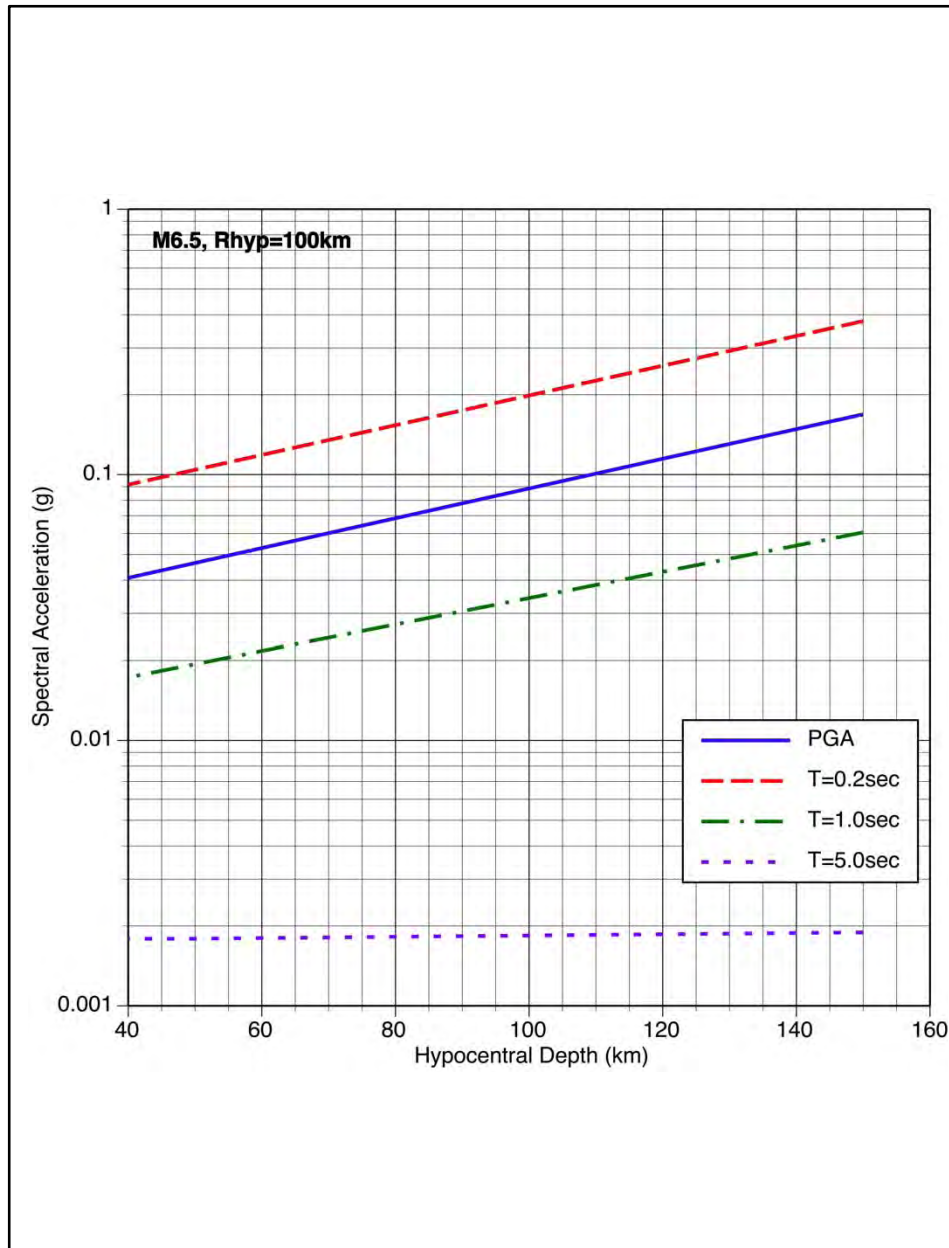




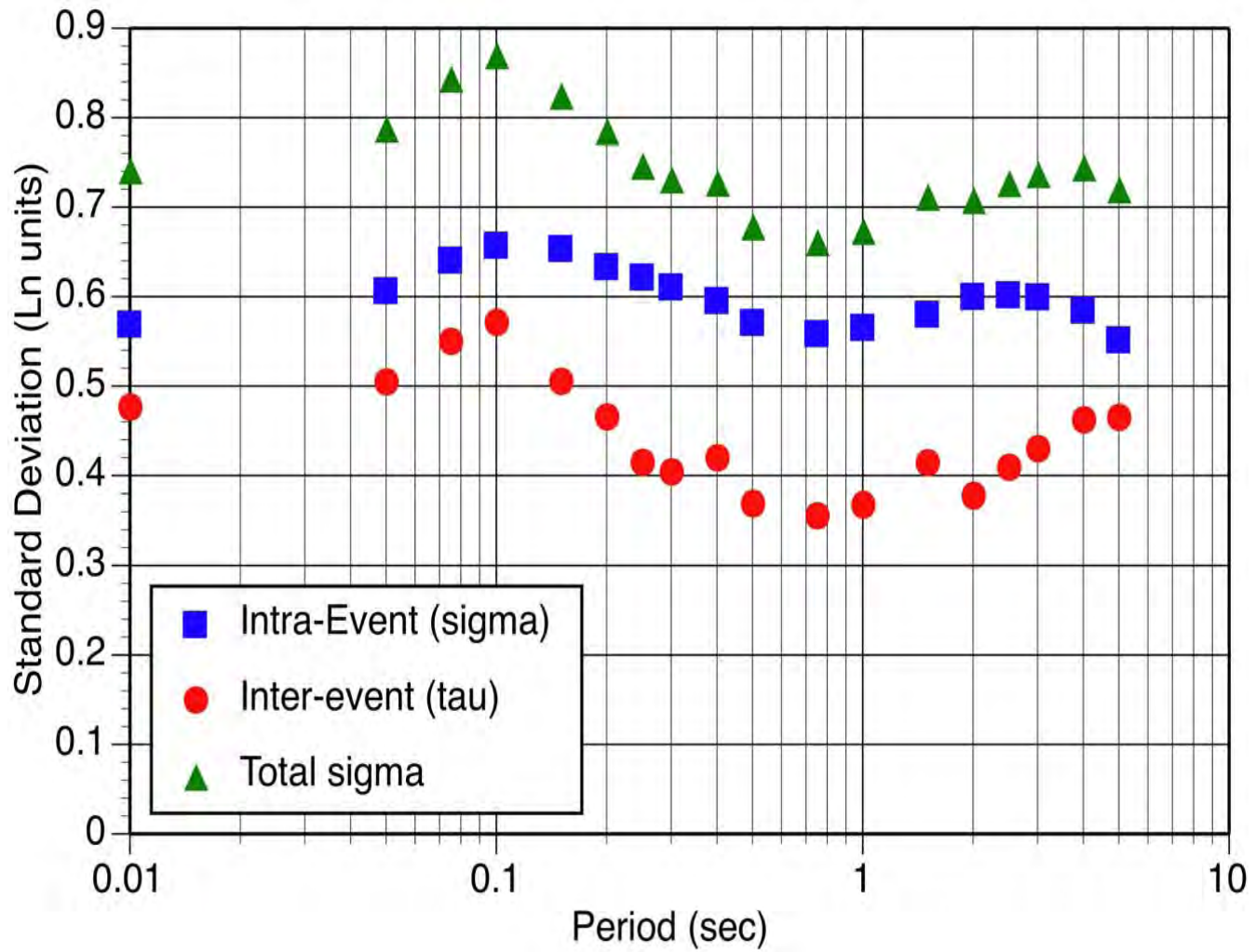


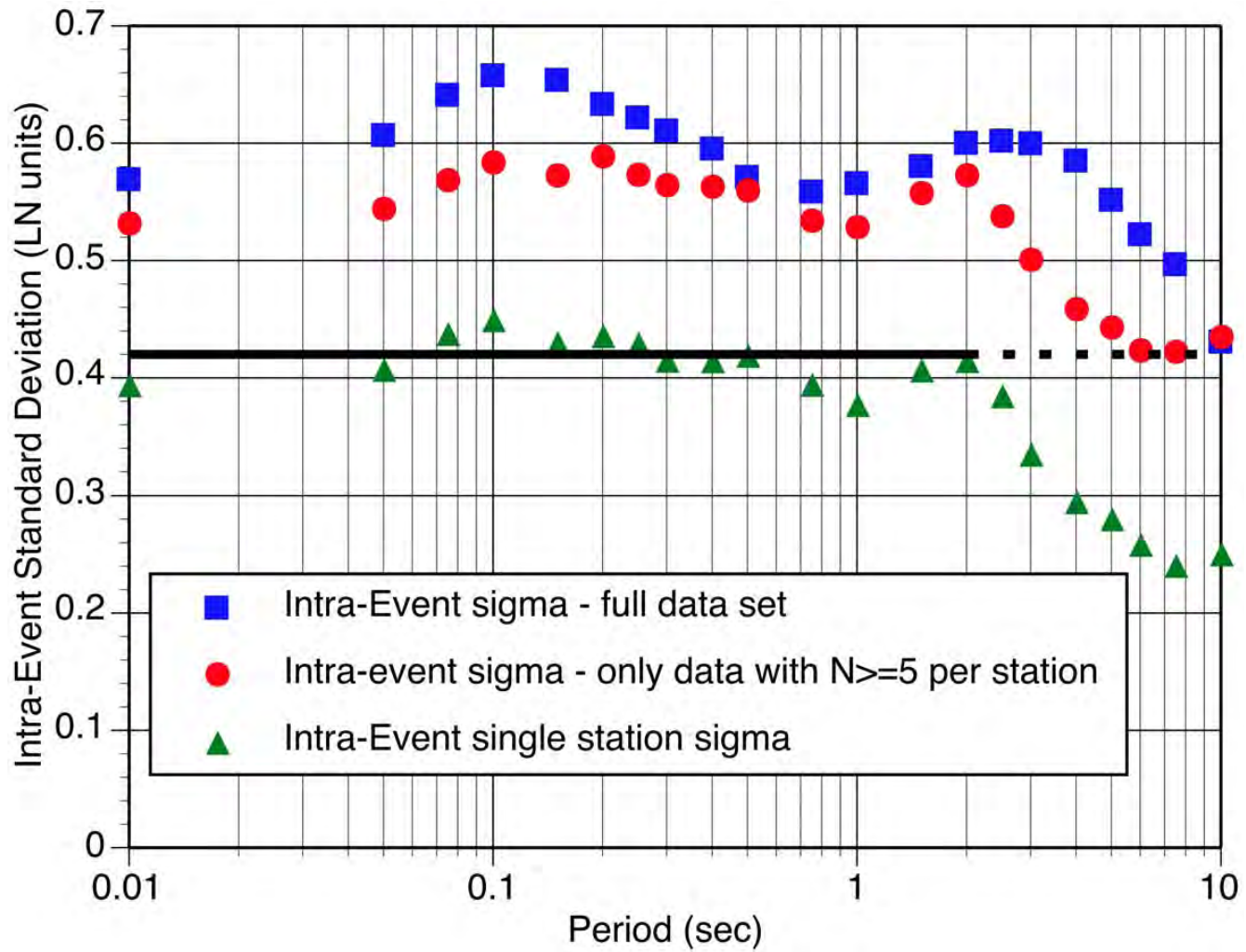


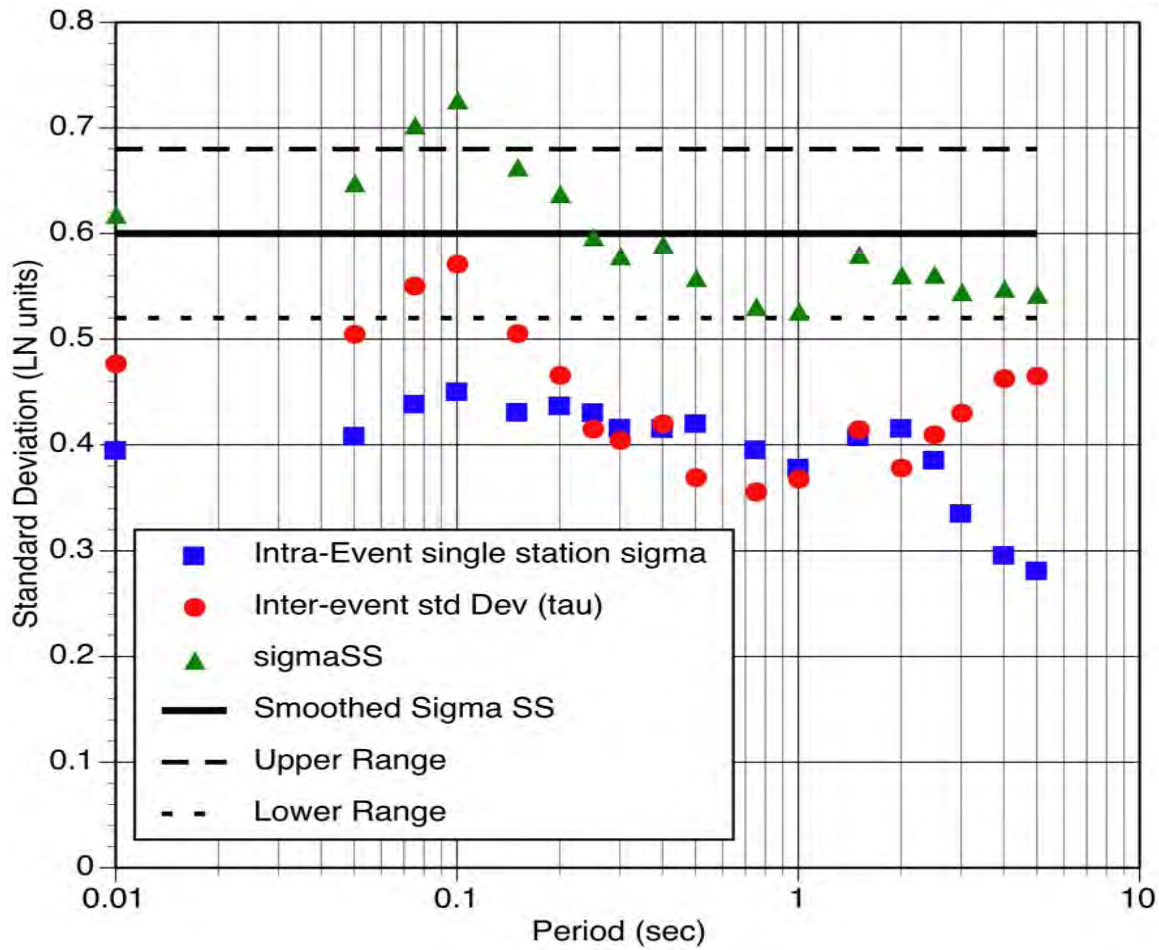




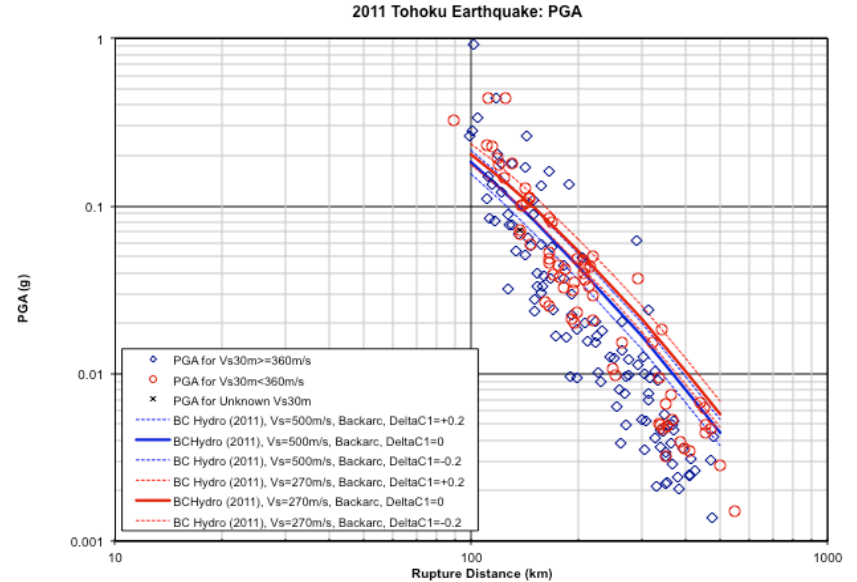
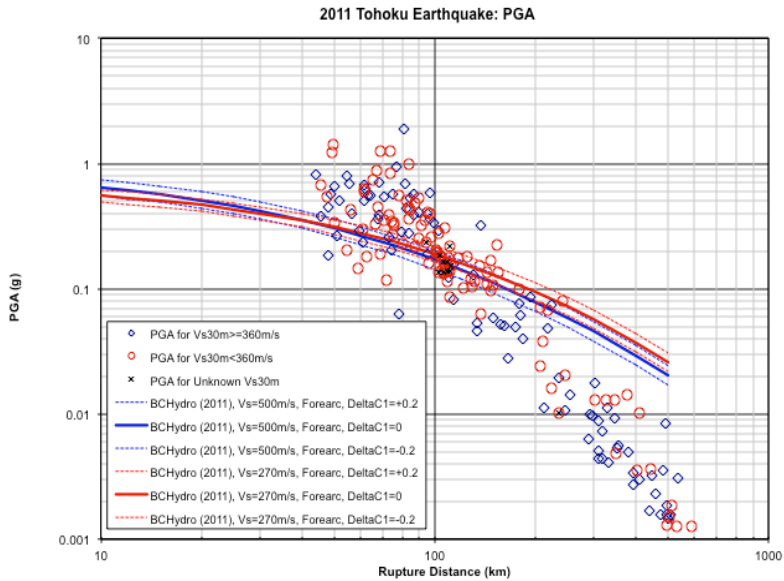
| | | | | |
|---|-----------|----------------|---|--|
| BChydro PSHA07DS Ground Motion Modelling Report | | | Hypocentral depth dependence for PGA and spectral periods of 0.2, 1.0, and 5.0 seconds from a magnitude 6.5 earthquake at a hypocentral distance of 100 km for Forearc site locations | Fig. 3-44 REPORT No.: E658-3 |
| DSGN: NAA | CHKD: NJG | DATE: Nov 2010 | | |



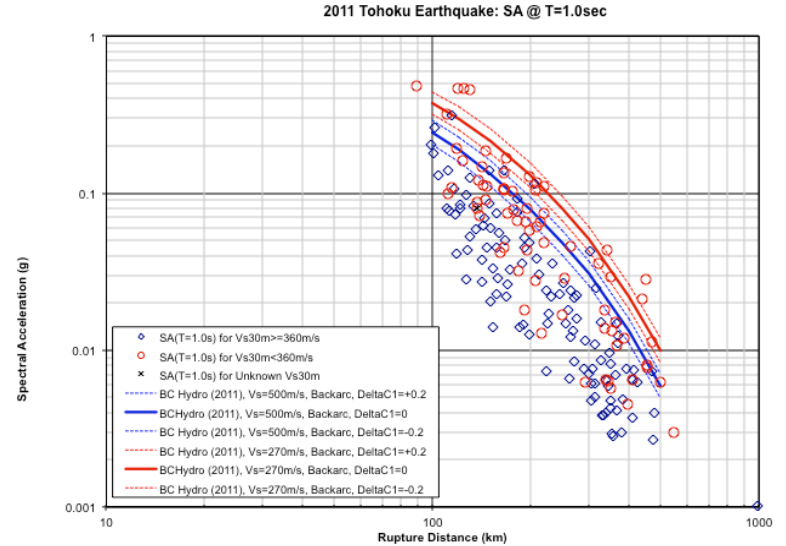
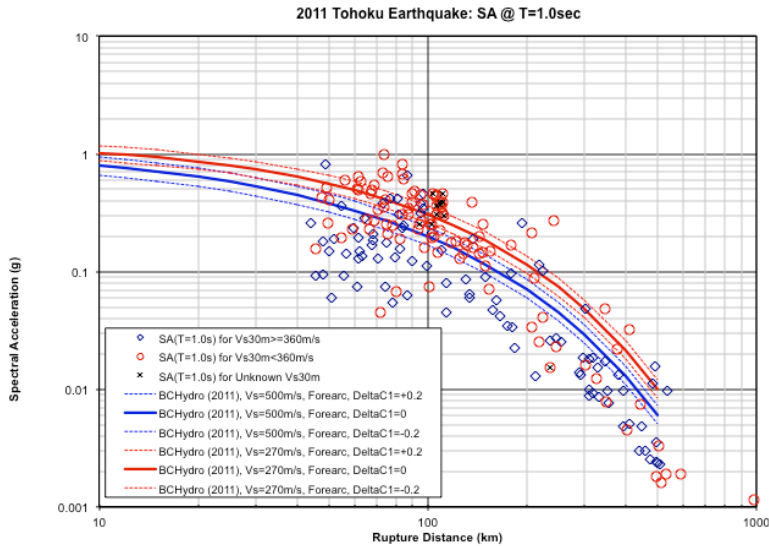




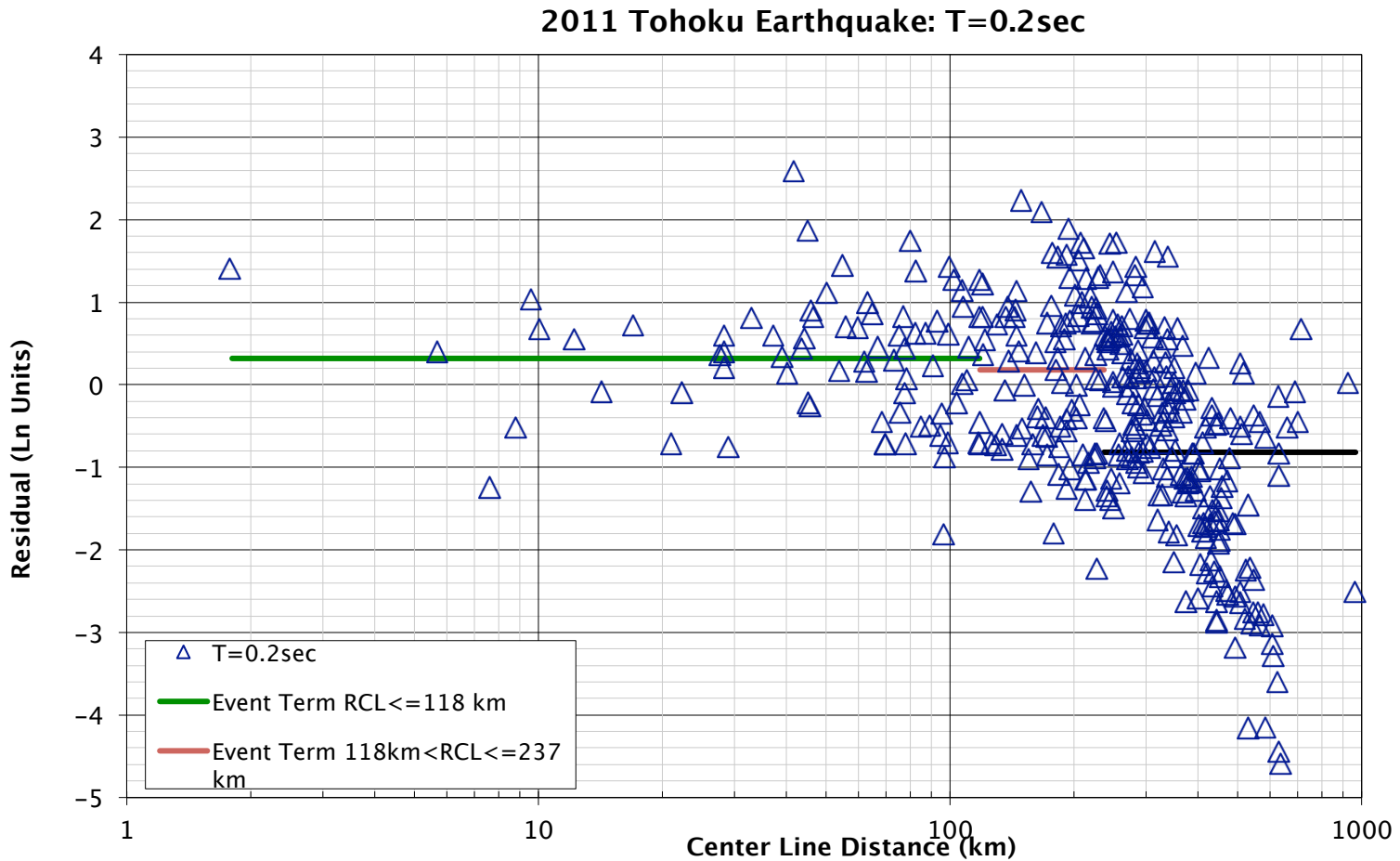
Tohoku (PGA)



Tohoku (T=1 sec)

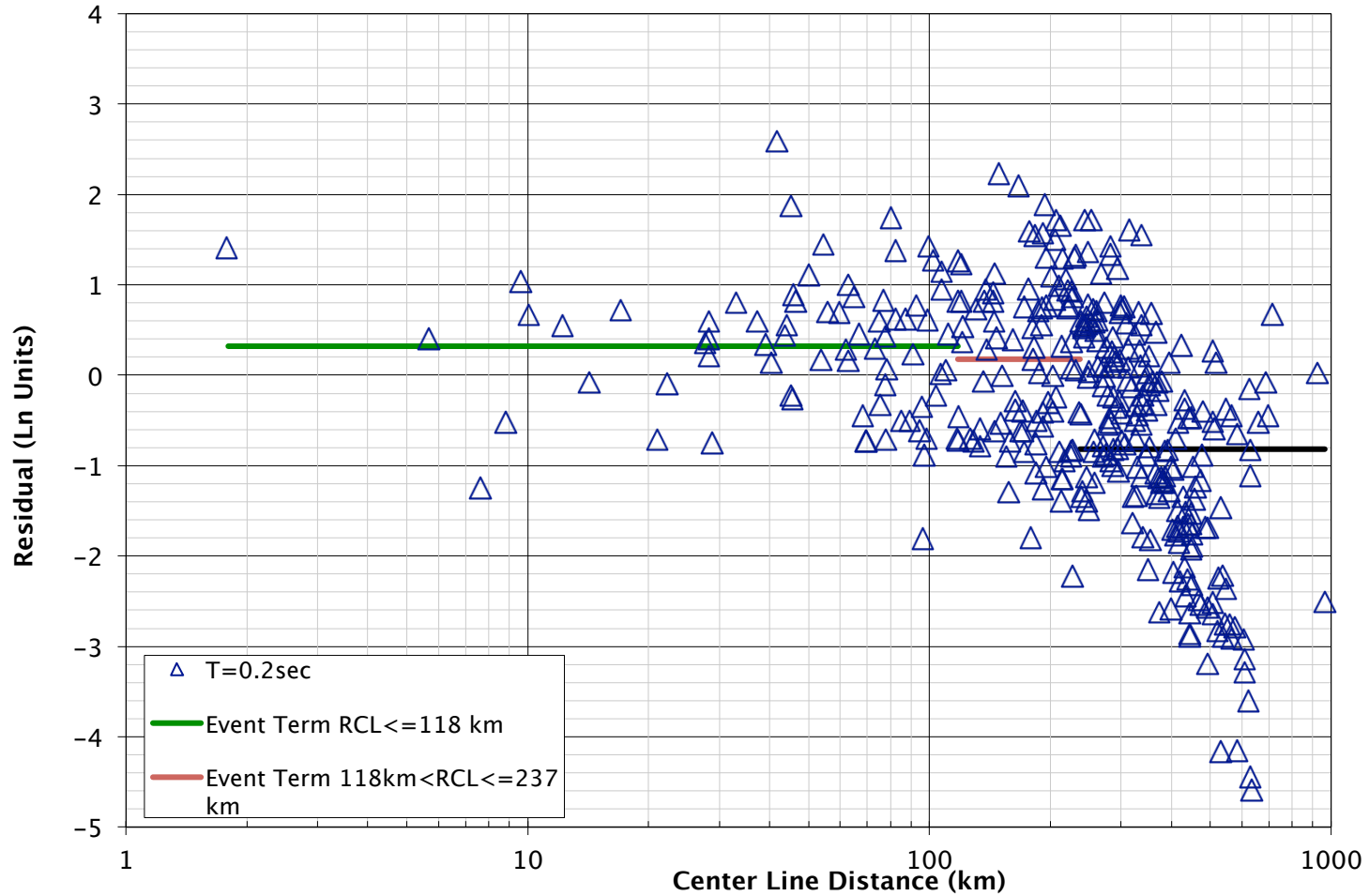


Tohoku (PGA)

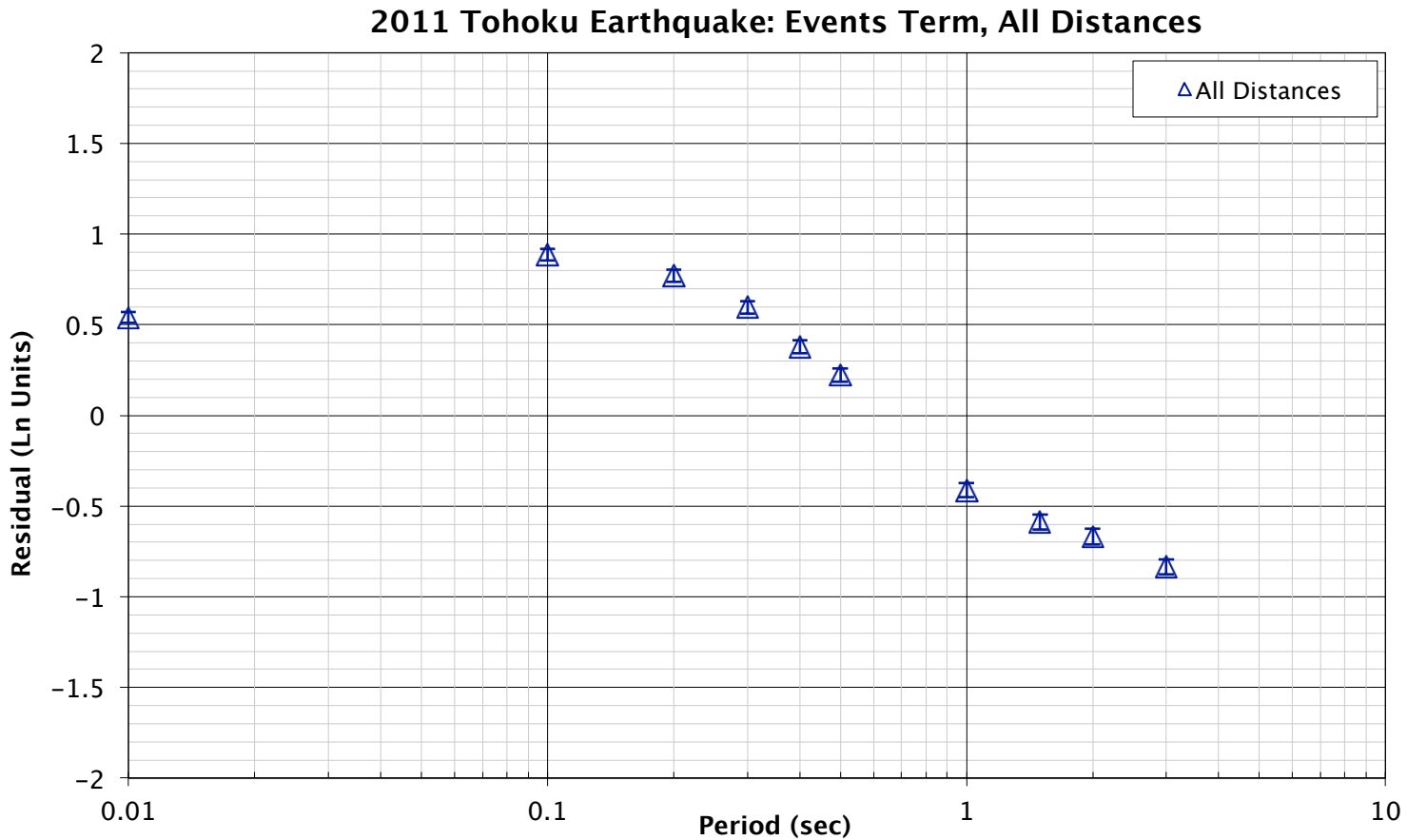


Tohoku (T=1 sec)

2011 Tohoku Earthquake: T=0.2sec

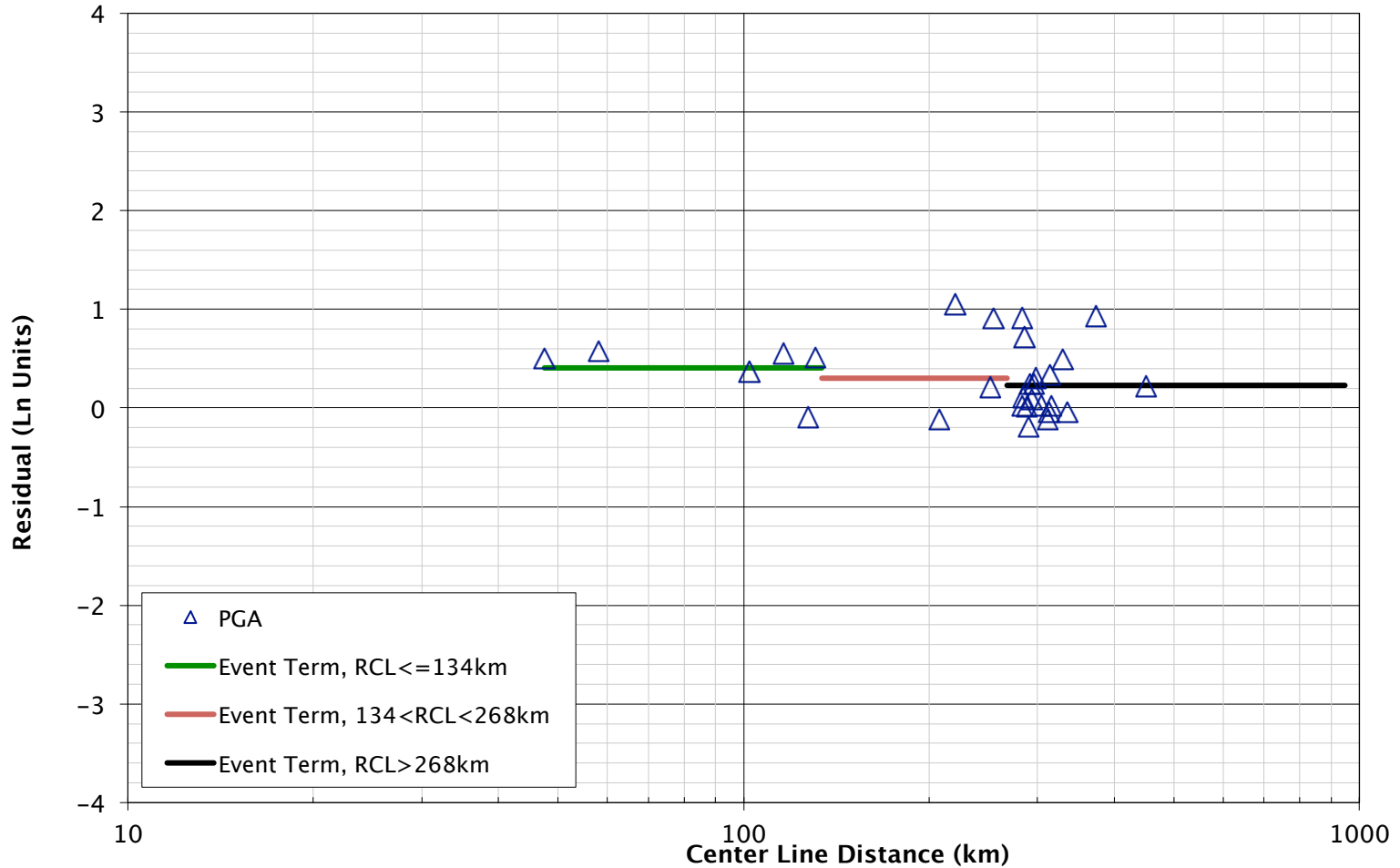


Tohoku ($R_{rup} < 100$ km)



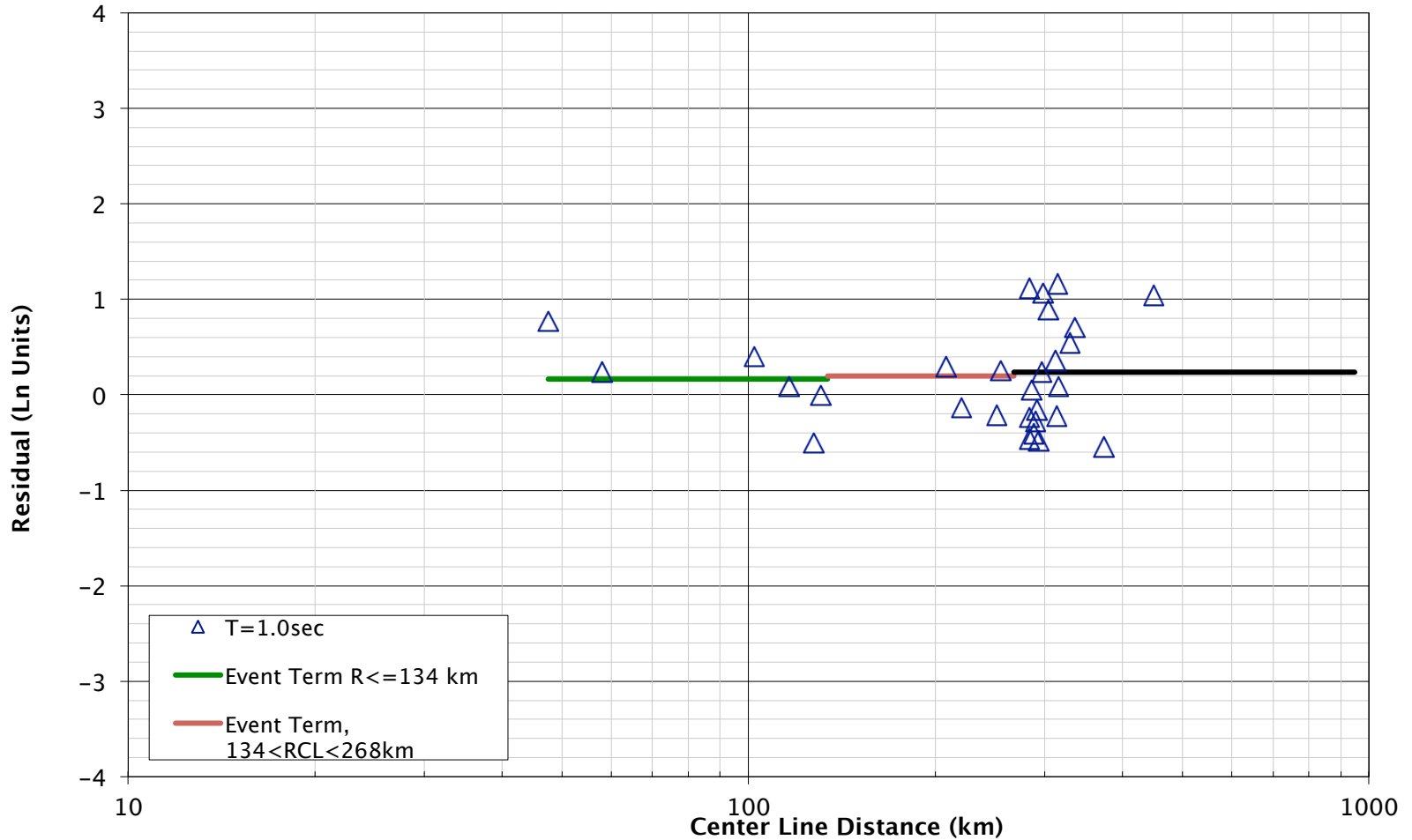
2010 Chile (PGA)

2010 Chile Earthquake: PGA



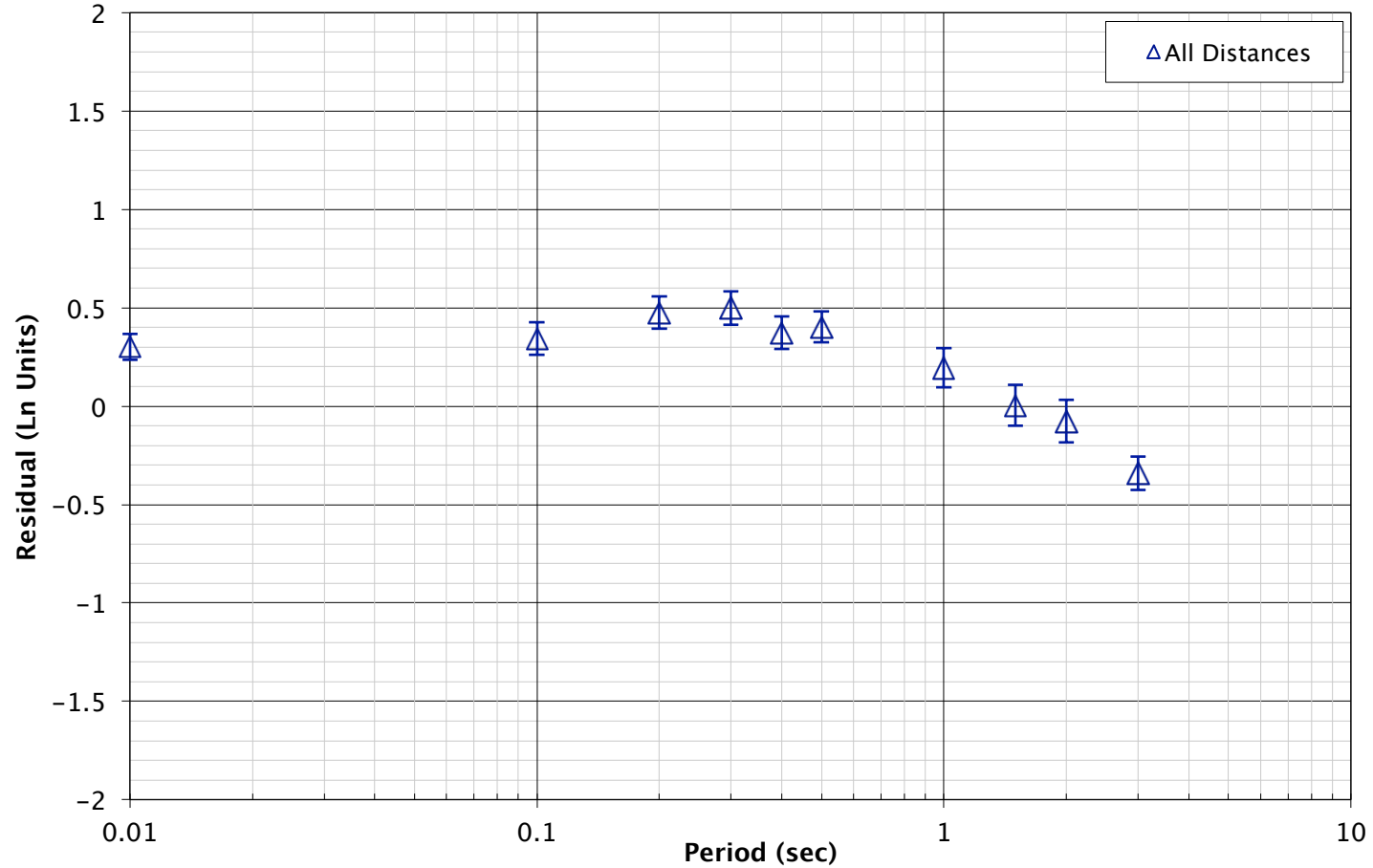
2010 Chile (T=1 sec)

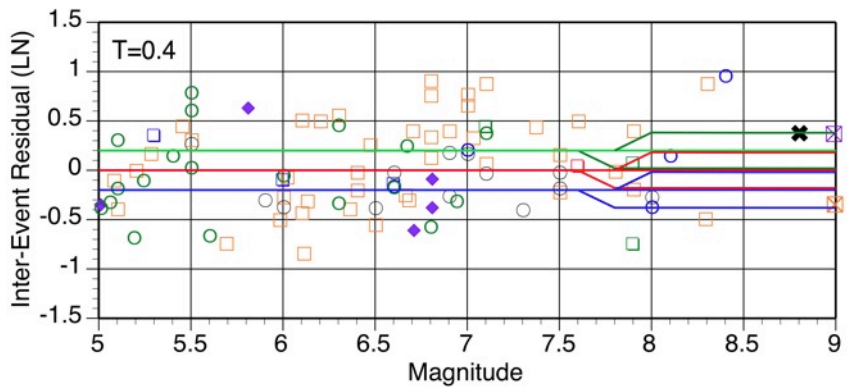
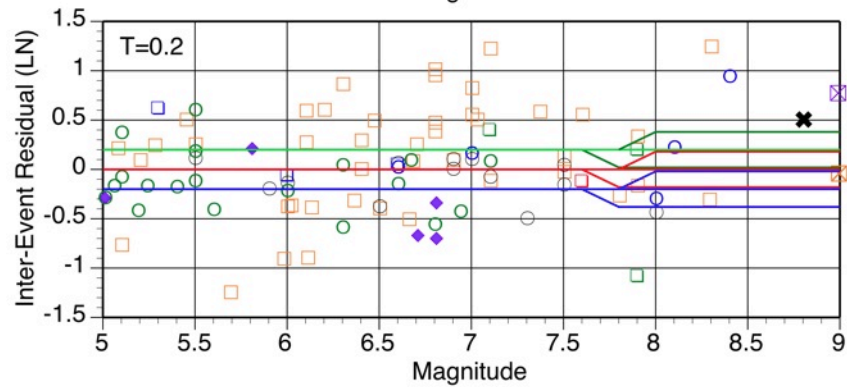
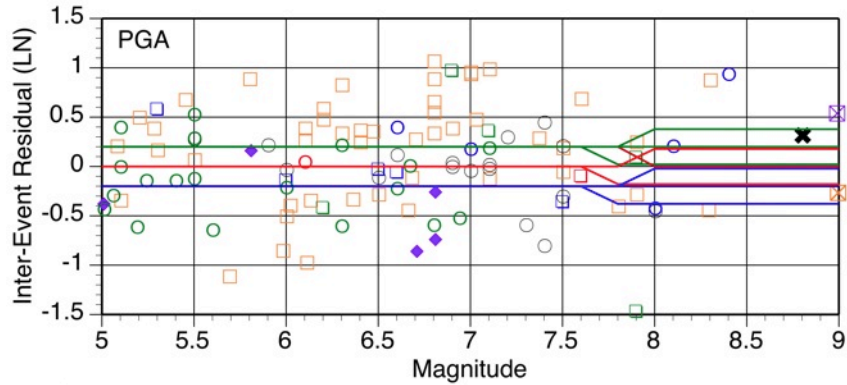
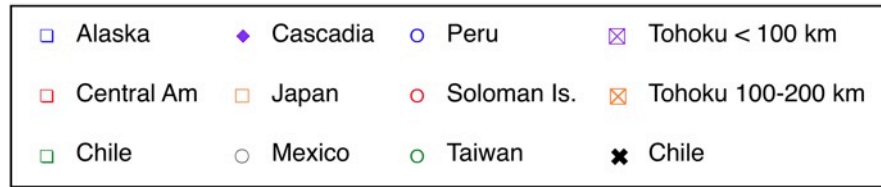
2010 Chile Earthquake: T=1.0sec

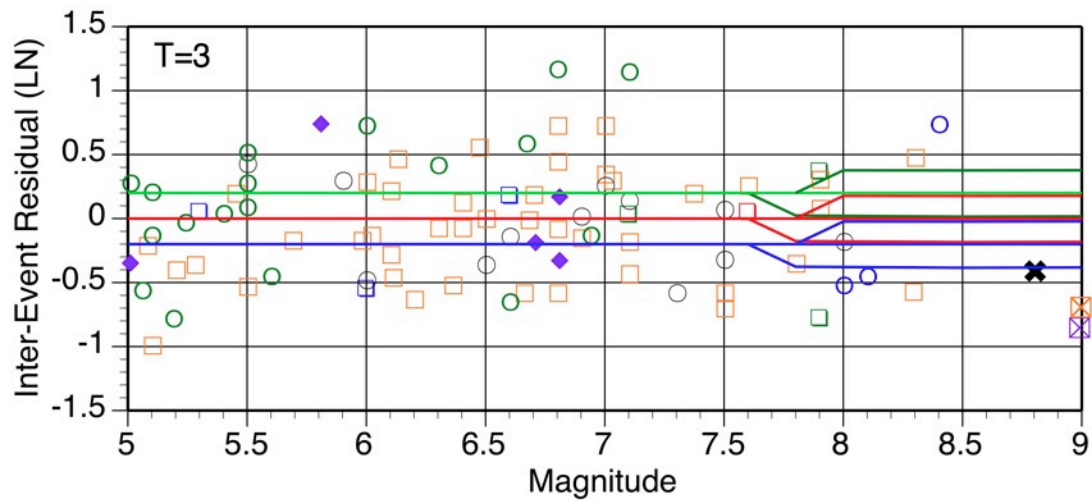
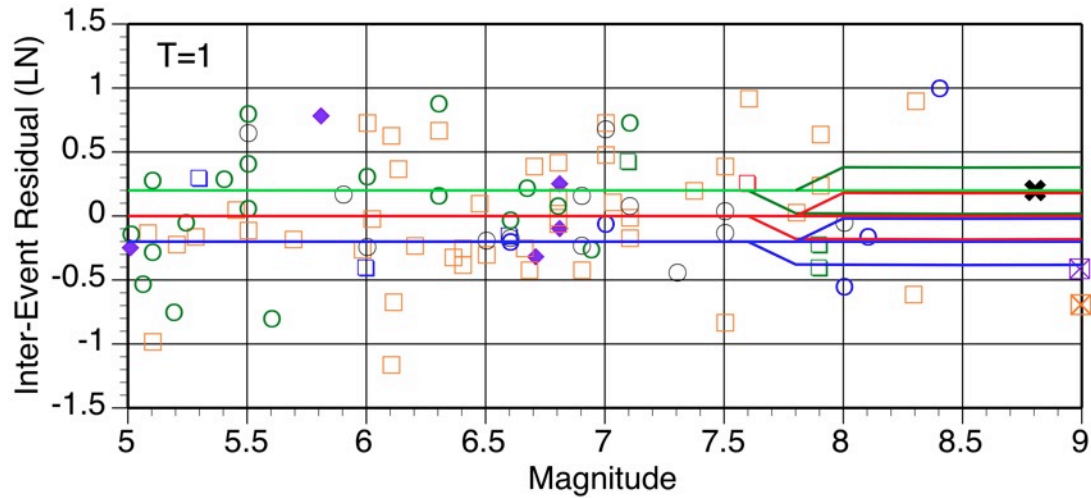
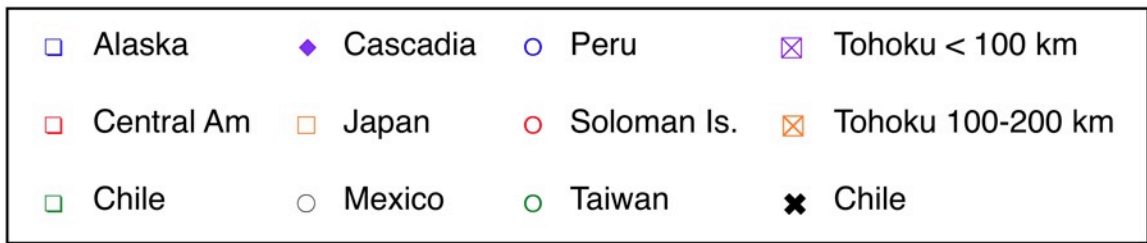


2010 Chile

2010 Chile Earthquake: Events Term, All Distances (29 pts)



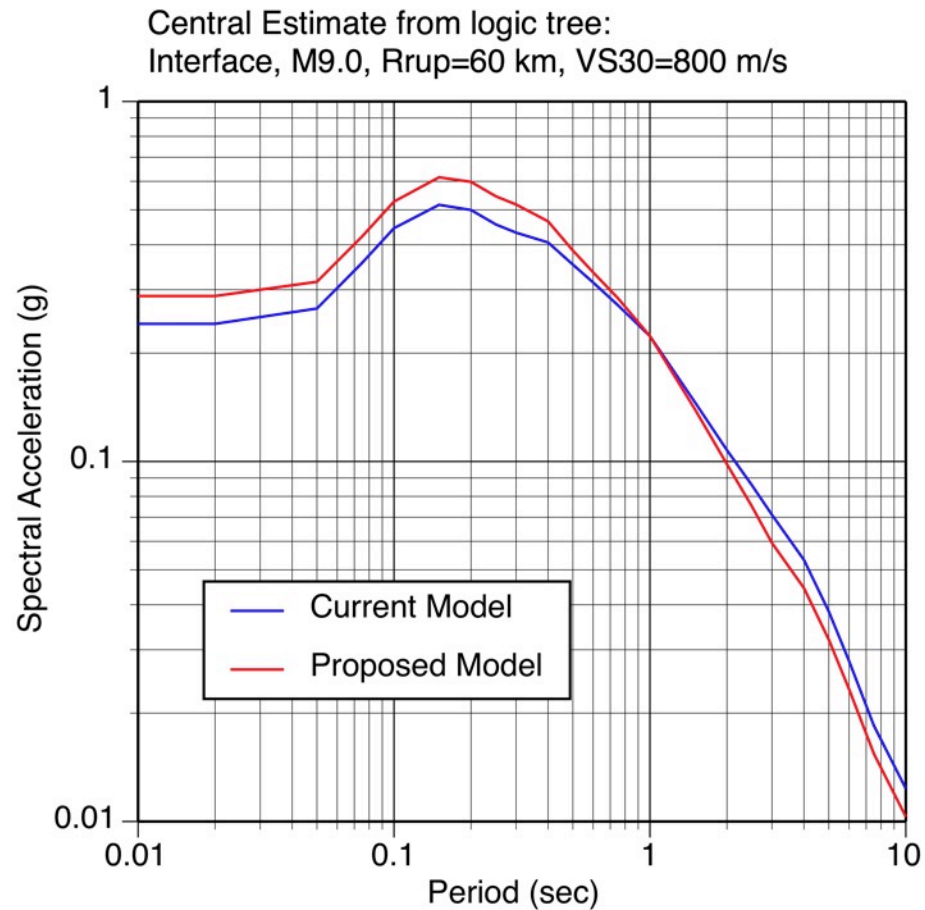




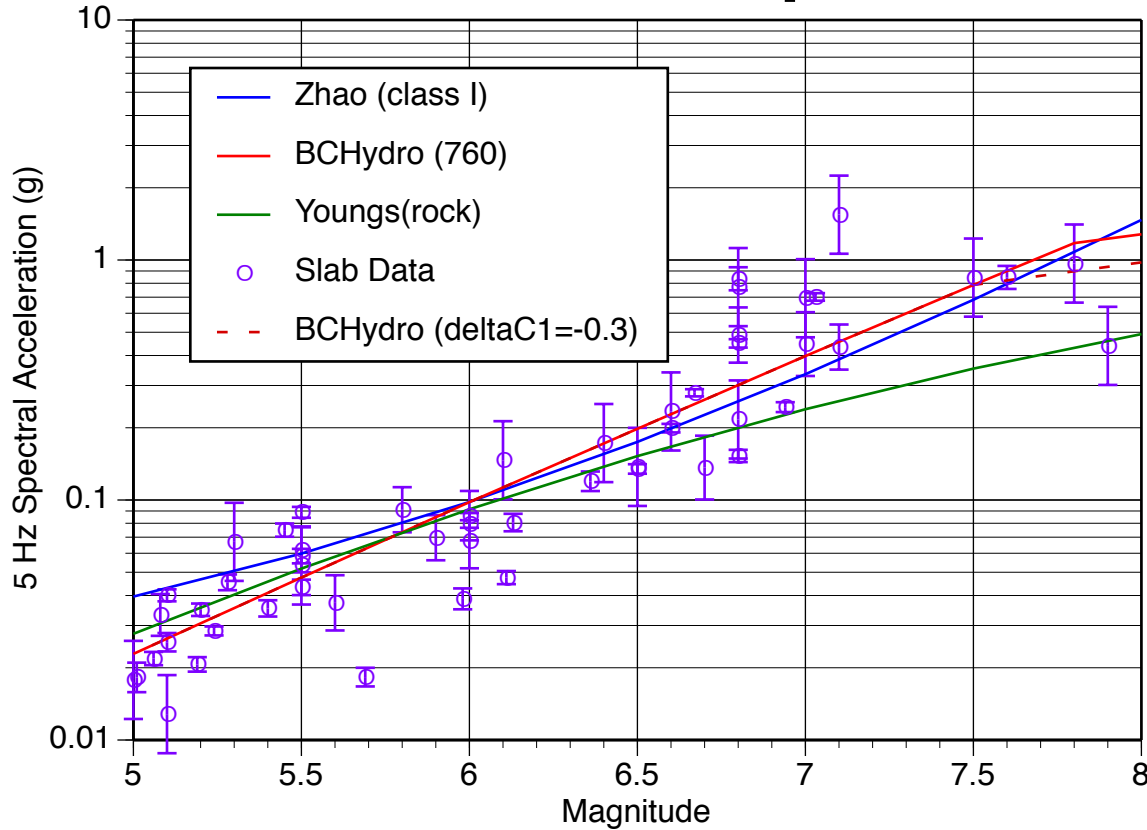
Revision to DeltaC1 Terms for Mega Thrust

| Period (sec) | Lower Value | Central Value | Upper Value |
|--------------|-------------|---------------|-------------|
| PGA | 0.0 | 0.2 | 0.4 |
| 0.3 | 0.0 | 0.2 | 0.4 |
| 0.5 | -0.1 | 0.1 | 0.3 |
| 1.0 | -0.2 | 0.0 | 0.2 |
| 2.0 | -0.3 | -0.1 | 0.1 |
| 3.0 | -0.4 | -0.2 | 0.0 |

Effect of Change in Delta C1



Break in Mag Scaling for Slab Eqk?



For Slabs Eqk

Lower: $\Delta C1 = -0.5$

Central: $DC1 = -0.3$

Upper: $DC1 = -0.1$

Strengths and Weaknesses

- Strengths
 - Based on large data base with consistent meta data
 - Allows for adjustment of scaling at large magnitudes through $\Delta C1$ term
 - Evaluates regional variation in constant term
- Weaknesses
 - No regional variation in VS30 scaling and gamma (Q) terms
 - No R_y dependence, over-estimates ground motion off end of megathrust
 - Forearc/backarc scaling may also reflect different gamma term in Japan

