Taiwan SSHAC Level 3 Study
Current GMC Logic Tree and Hazard Feedback

PTI

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Taiwan SSHAC Level 3 PSHA Study
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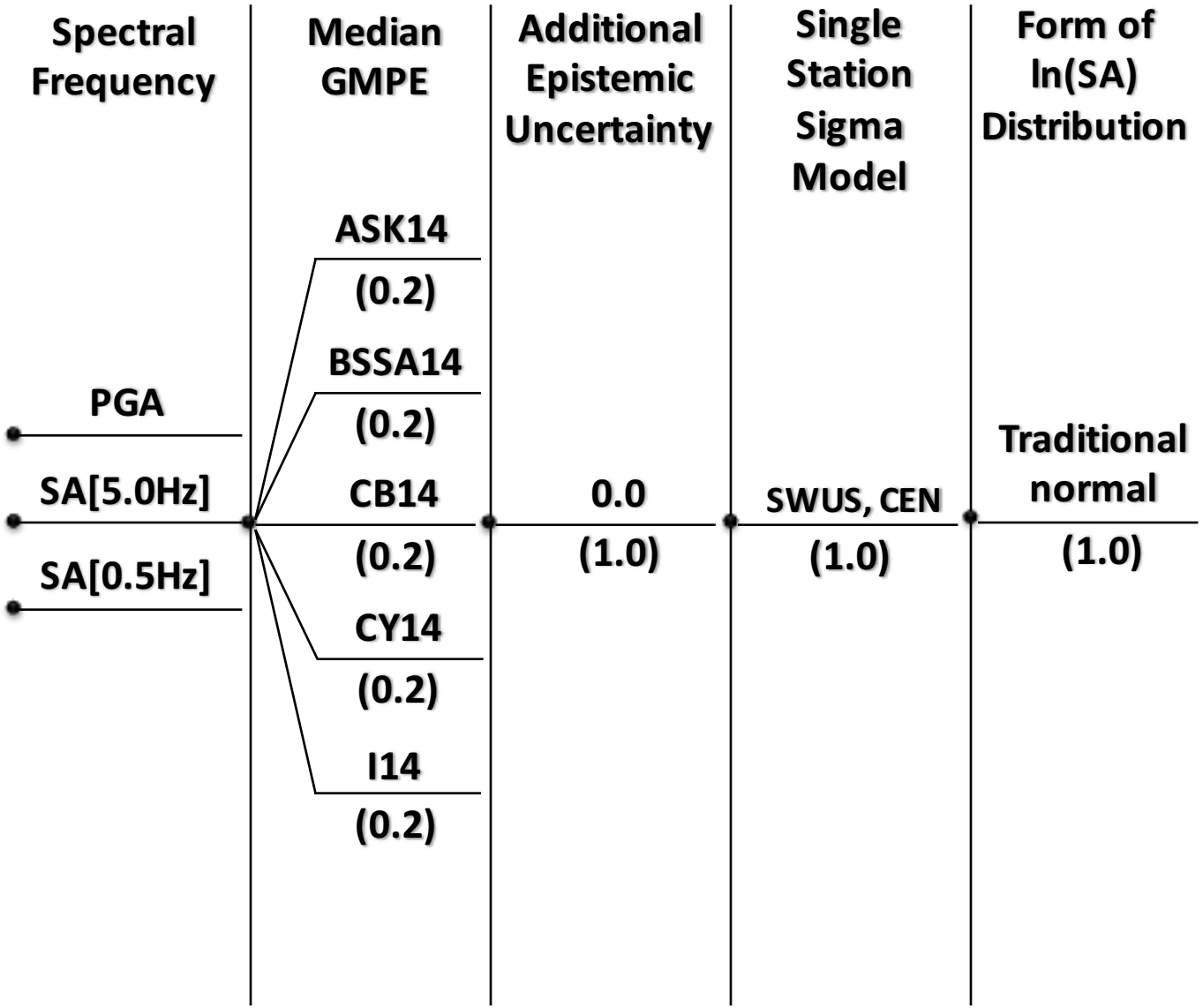
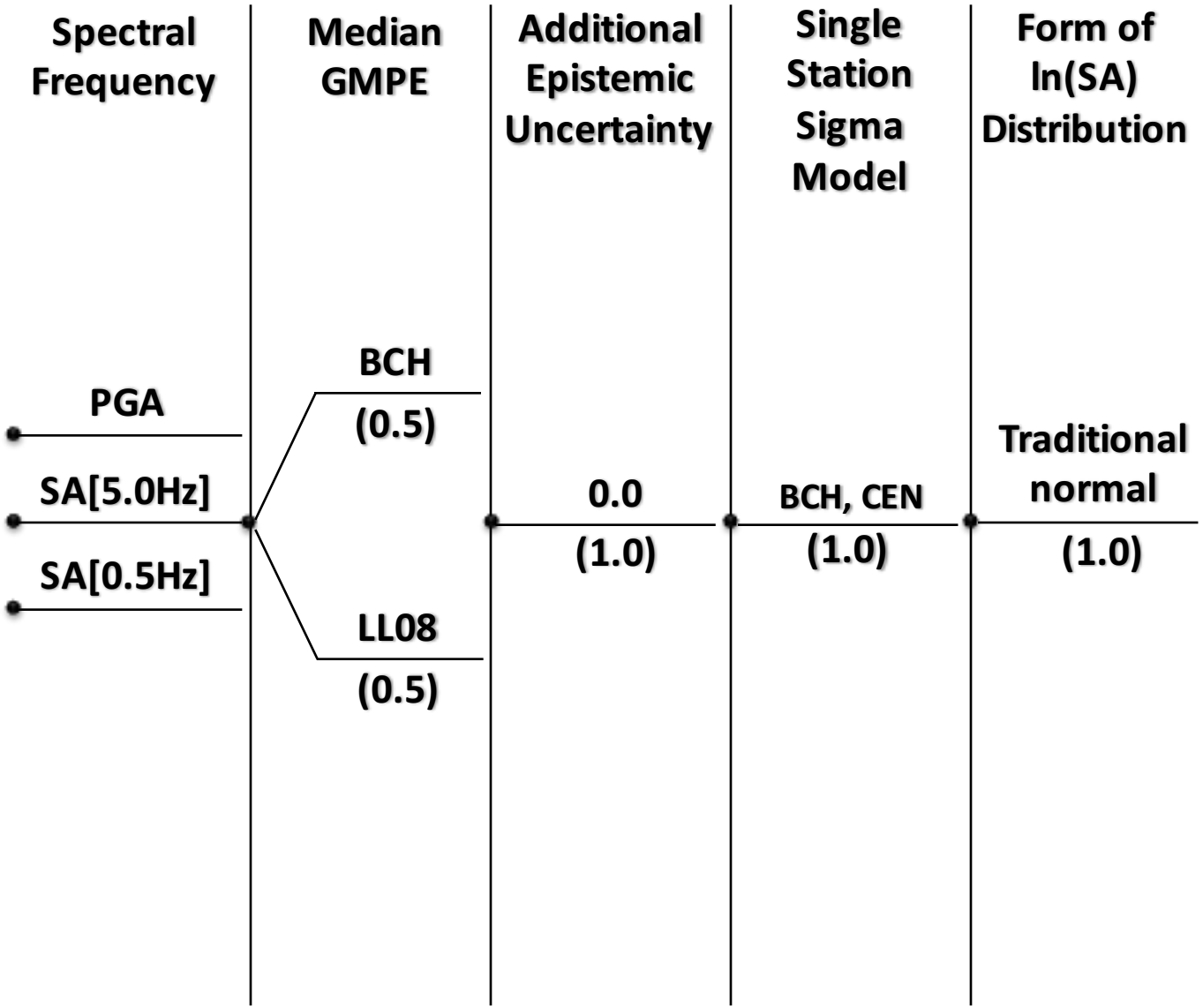
Outline

- **Basecase**
- **Hazard curves and deaggregation(PGA, 2s)**
- **Current GMC Logic Tree**
- **GMC Sensitivity**
  - Tornado plot
  - For Adjusted Models - median

GMC Crustal base case



GMC Subduction base case

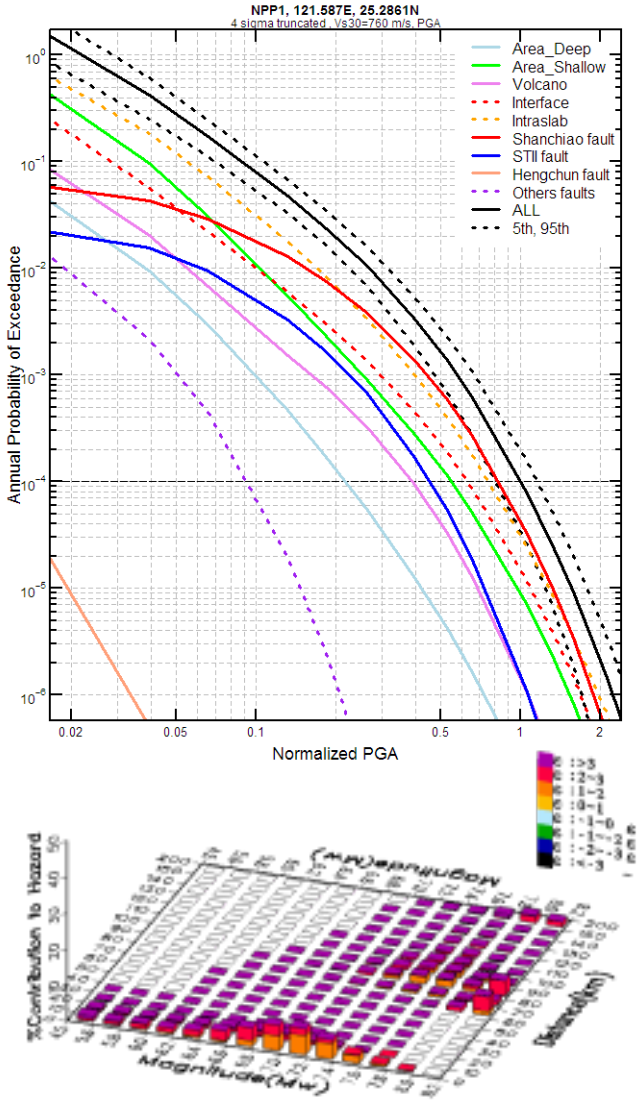


Because the sources is under working, the SSC team suggested that we used the sources same as WS #2.

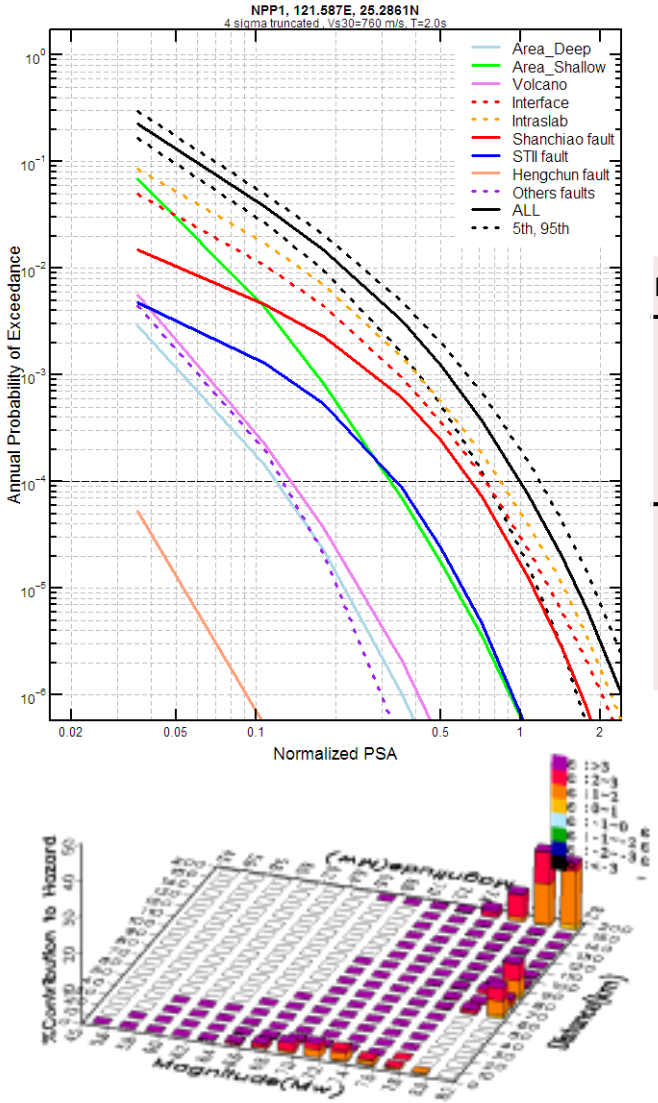
HAZARD DEAGGREGATION

NPP1 - PGA - 5Hz – 0.5Hz

PGA



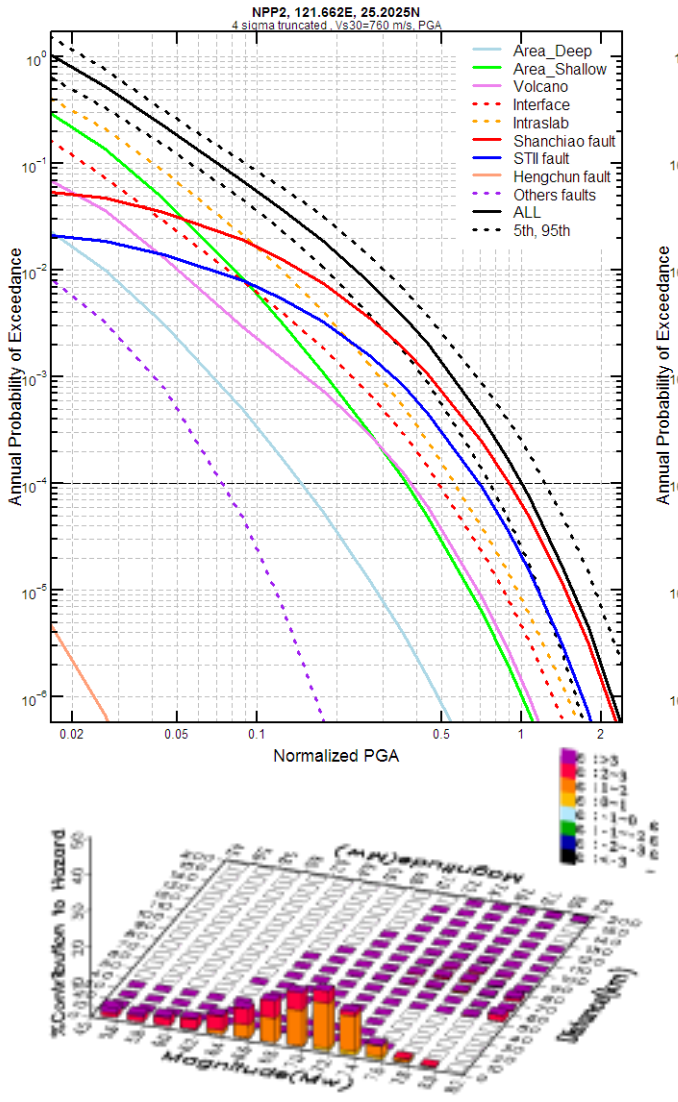
2.0s



Period	Source	M	R
PGA	Shanchiao (42%)	6.6-7.4	0-10
	Intraslab (31%)	7.4-8.0	70-100
	Interface (15%)	8.0-8.2	60-80
2s	Intraslab (52%)	7.5-8.2	150-230
	Interface (30%)	8.4-9.0	60-80
	Shanchiao (17%)	7.0-7.4	0-10

NPP2 - PGA - 5Hz – 0.5Hz

PGA



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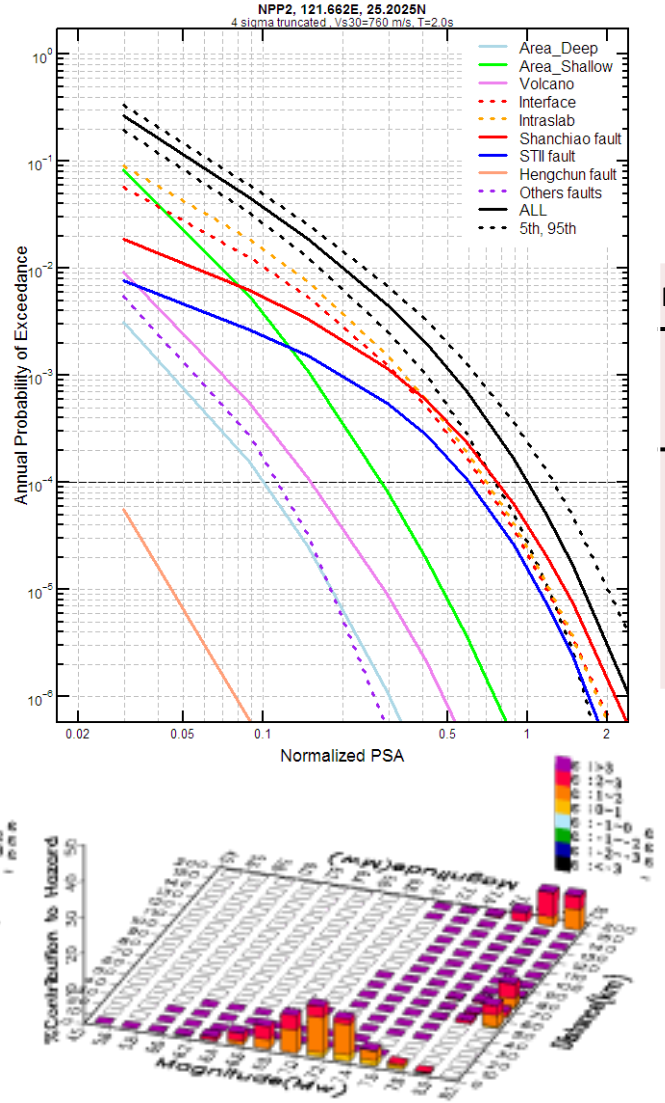
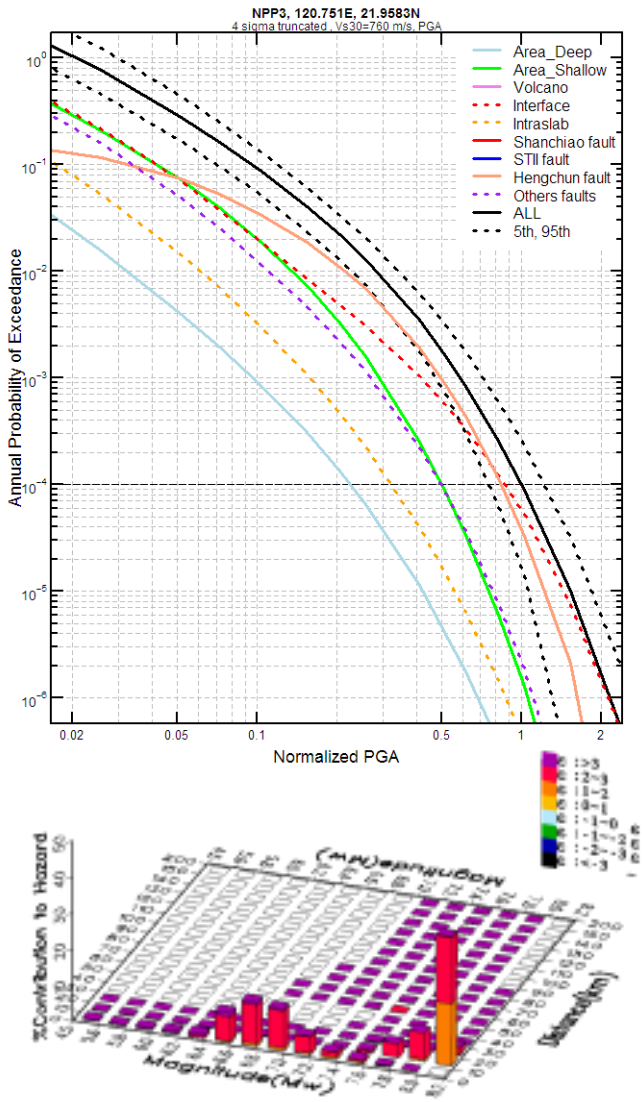


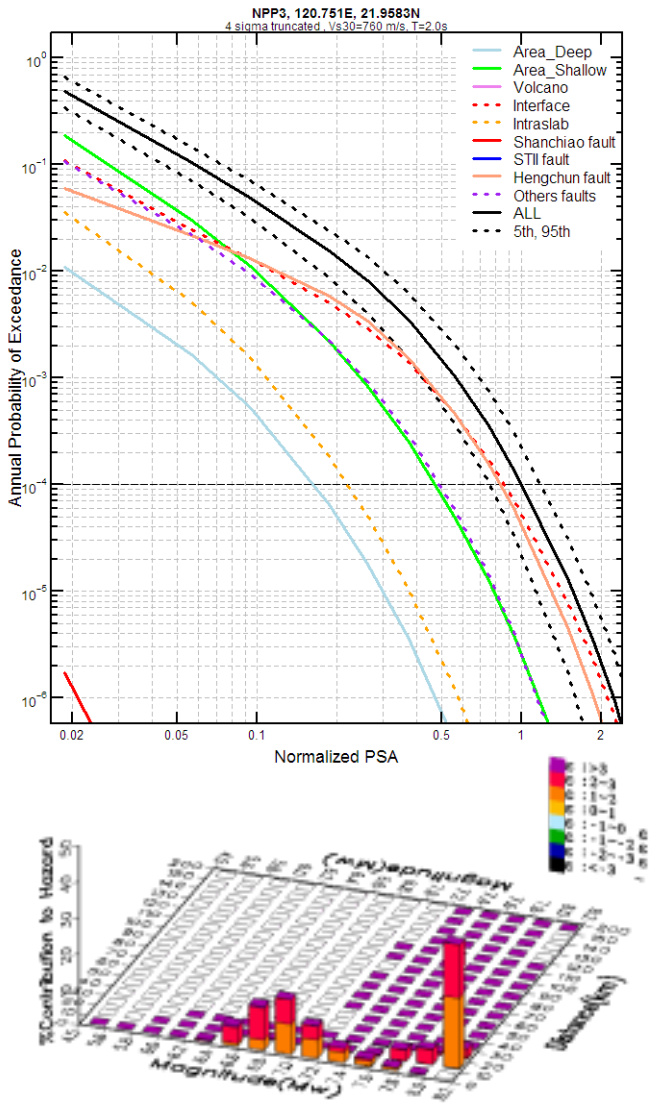
Period	Source	M	R
PGA	Shanchiao (62%)	6.4-7.4	0-10
	STII (20%)	6.4-7.4	0-10
2s	Shanchiao (38%)	7.0-7.4	0-10
	Intraslab (24%)	7.5-8.2	150-230
	Interface (22%)	8.4-9.0	50-80
	STII (16%)	7.0-7.4	0-10

NPP3 - PGA - 5Hz – 0.5Hz

PGA



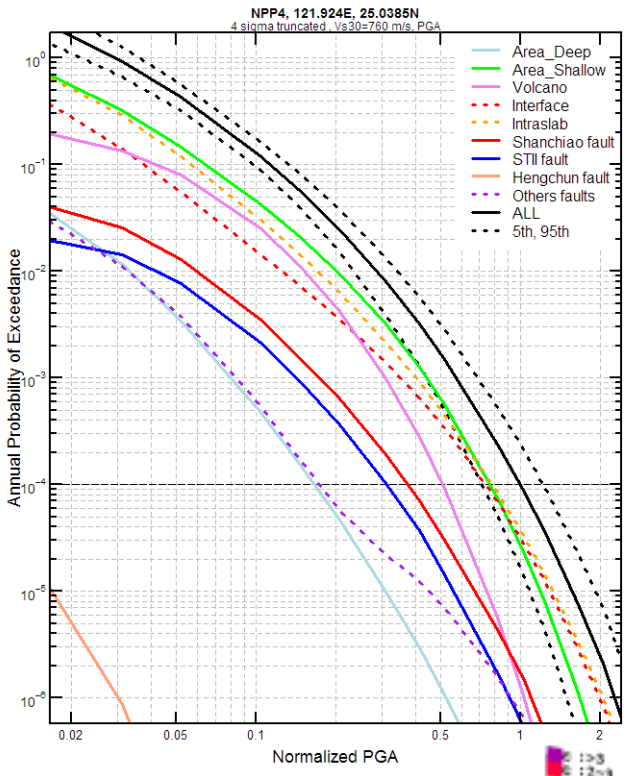
2.0s

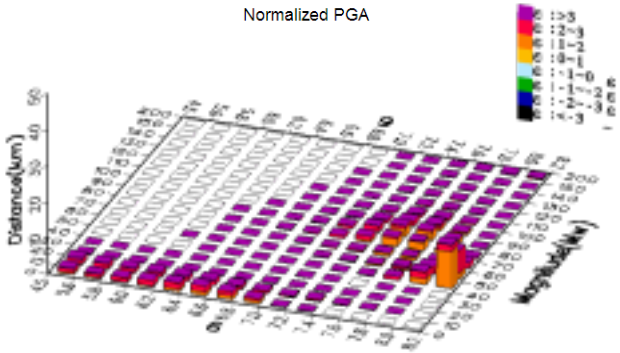


Period	Source	M	R
PGA	Interface (53%)	8-8.8	10-20
	Hengchun (43%)	6.4-7.2	0-10
2s	Interface (46%)	8-8.8	10-20
	Hengchun (48%)	6.6-7.6	0-10

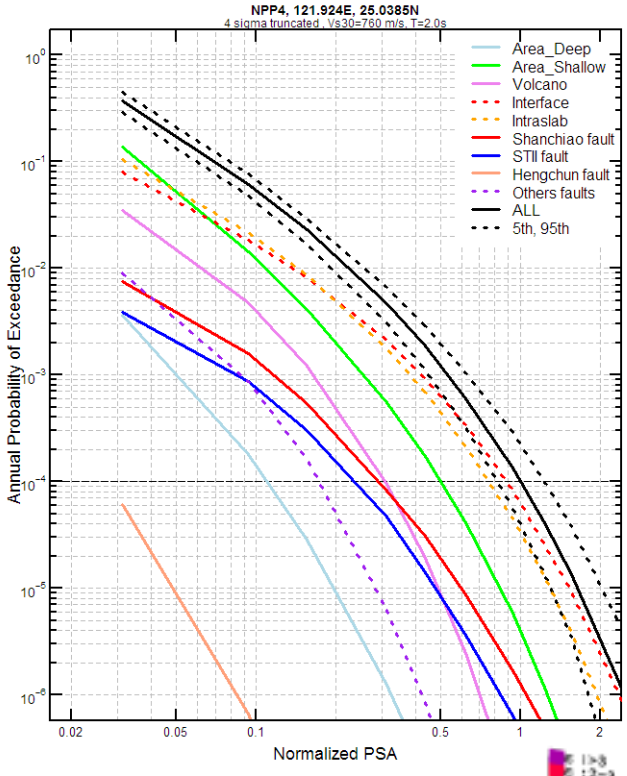
NPP4 - PGA - 5Hz – 0.5Hz

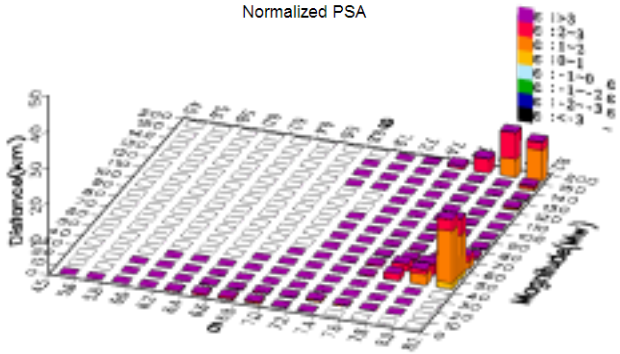
PGA





2.0s





Period	Source	M	R
PGA	Intraslab (37%)	7.5-8.0	70-100
	Interface (32%)	8.2-9.0	40-70
	Shallow area (26%)	5-7	0-20
2s	Interface (61%)	8-9	40-60
	Intraslab (33%)	7.5-8.2	150-230

CURRENT GMC LOGIC TREE

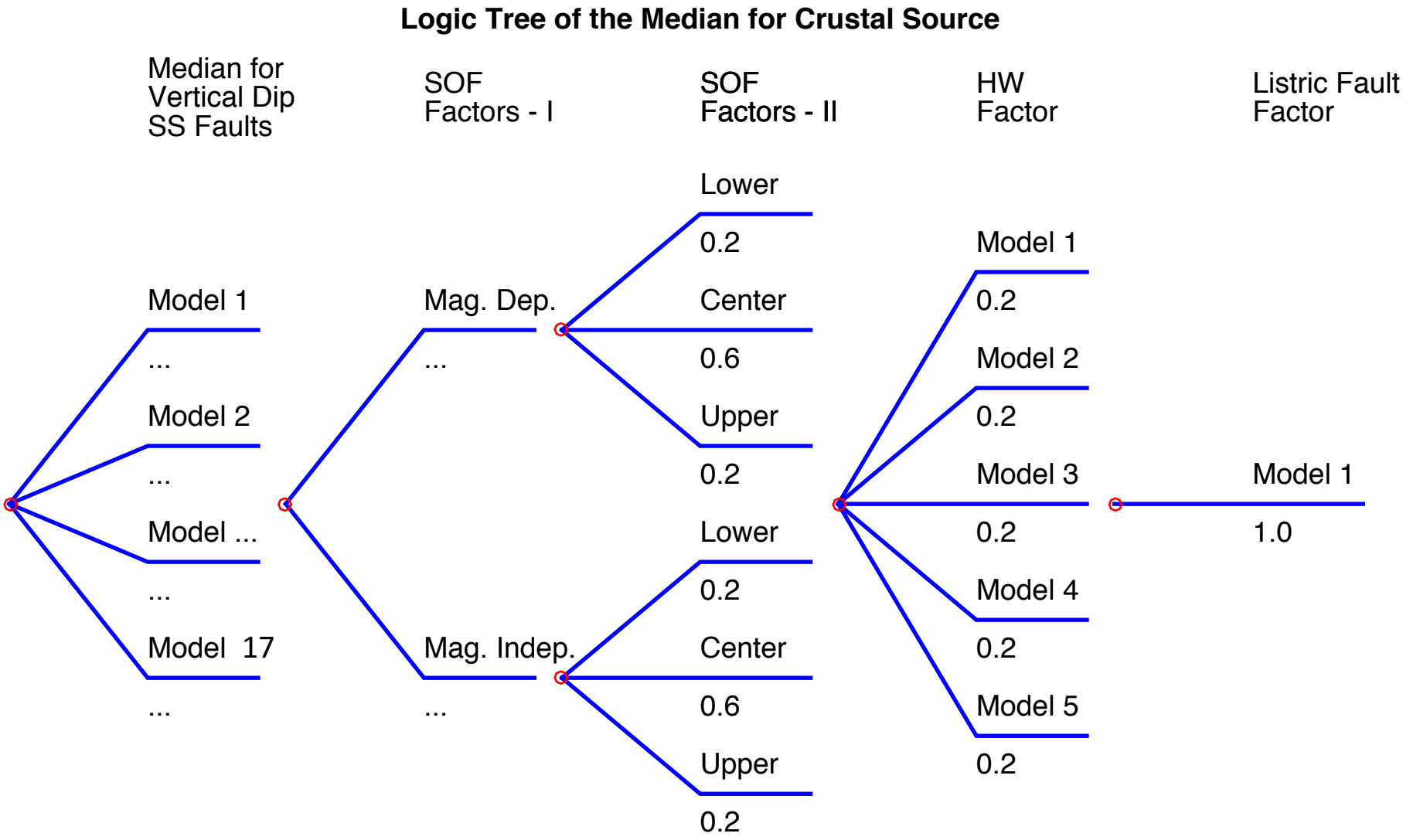
GMC Sensitivity results – Crustal – PGA(WM#3)

Node	GMPEs used in Sensitivity	GM Ratio greater than 10%			
		NPP1	NPP2	NPP3	NPP4
✔ 1	GMPE for Median	✔	✔	✔	✔
✔ 2	Additional Epistemic Uncertainty for Median	✔	✔	✔	✔
✔ 3	SigmaSS	✔	✔	✔	✔
4	Form of Distribution of ln(SA)				
5	Splay fault (only for NPP3)				
6	Deep events				
7	Dip implementation for listric fault (only for NPP2)				
8	Directivity model (only for period larger than 0.5 sec)				
✔ 9	Style of Faulting	✔	✔	✔	✔
✔ 10	Hanging-wall Effect		✔	✔	

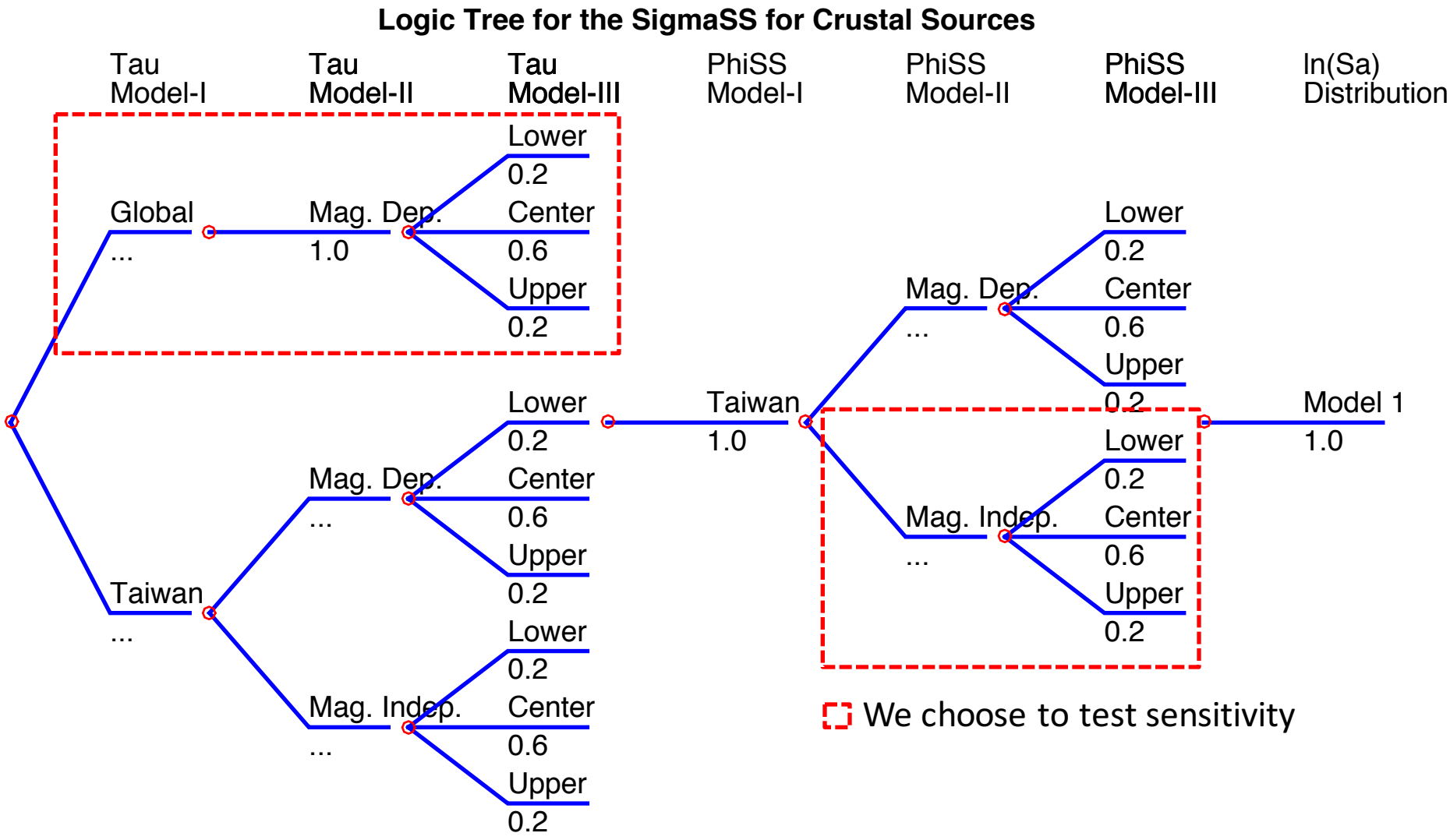
GMC Sensitivity results – Crustal – 2 sec(WM#3)

Node	GMPEs used in Sensitivity	GM Ratio greater than 10%			
		NPP1	NPP2	NPP3	NPP4
✔ 1	GMPE for Median	✔	✔	✔	✔
✔ 2	Additional Epistemic Uncertainty for Median	✔	✔	✔	✔
✔ 3	SigmaSS	✔	✔	✔	✔
4	Form of Distribution of ln(SA)				
5	Splay fault (only for NPP3)				
6	Deep events				
7	Dip implementation for listric fault (only for NPP2)				
8	Directivity model				
✔ 9	Style of Faulting	✔	✔	✔	✔
✔ 10	Hanging-wall Effect		✔		

Logic Tree of the Median for Crustal Source



Logic Tree of the SigmaSS for Crustal Source



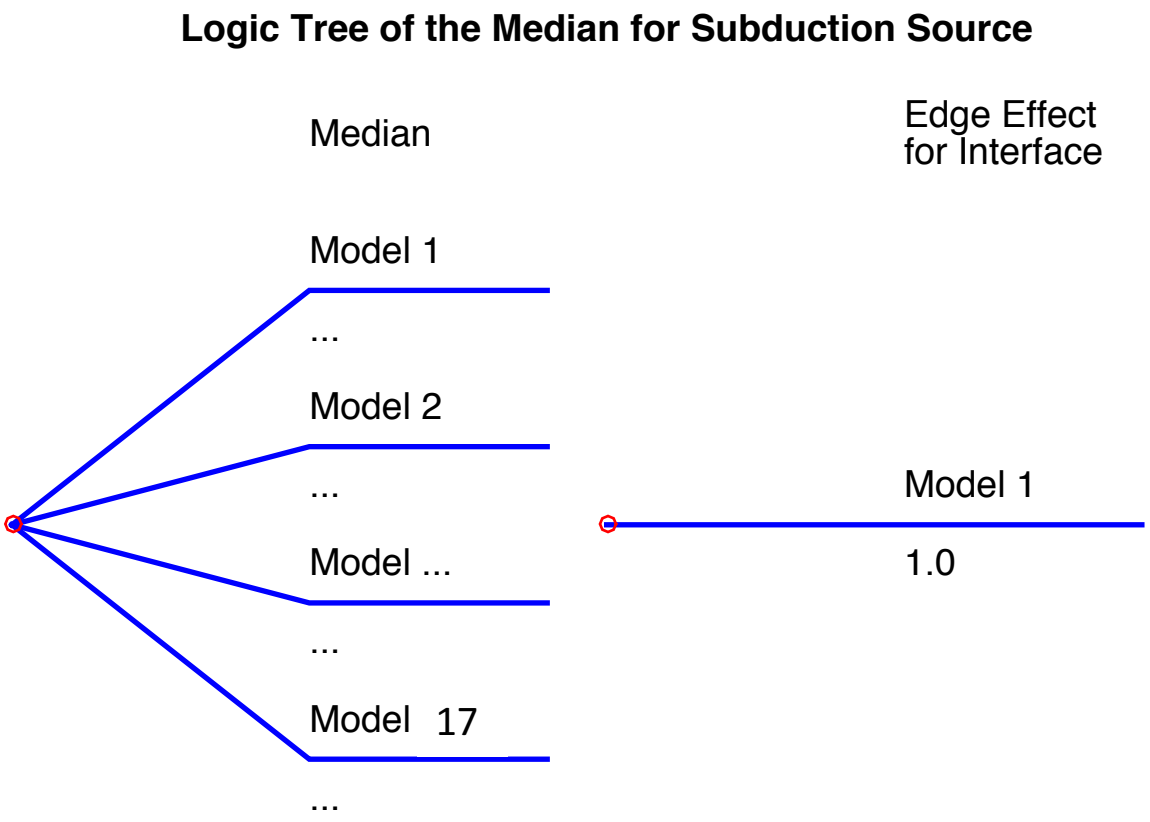
GMC Sensitivity results – Subduction – PGA

Node	GMPEs used in Sensitivity	GM Ratio greater than 10%			
		NPP1	NPP2	NPP3	NPP4
✔ 1	GMPE for Median	✔		✔	✔
✔ 2	Additional Epistemic Uncertainty for Median	✔	✔	✔	✔
✔ 3	SigmaSS				
4	Form of Distribution of ln(SA)				
5	Depth scaling for intraslab				
6	Large Mag scaling for intraslab				✔
7	Edge Effect for interface				

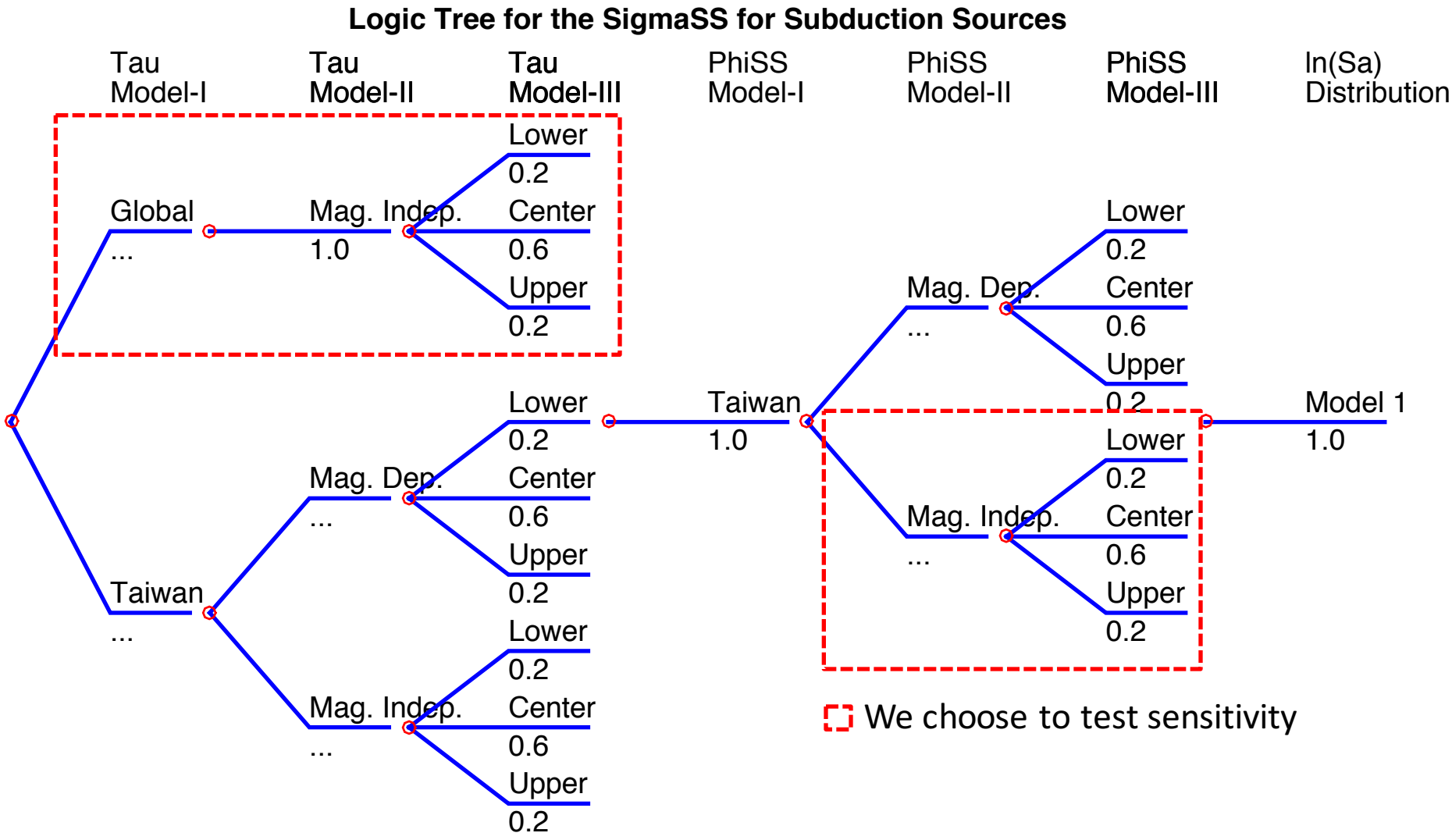
GMC Sensitivity results – Subduction – 2 sec

Node	GMPEs used in Sensitivity	GM Ratio greater than 10%			
		NPP1	NPP2	NPP3	NPP4
✔ 1	GMPE for Median	✔	✔	✔	✔
✔ 2	Additional Epistemic Uncertainty for Median	✔	✔	✔	✔
✔ 3	SigmaSS				
4	Form of Distribution of ln(SA)				
5	Depth scaling for intraslab				
6	Large Mag scaling for intraslab				
7	Edge Effect for interface				

Logic Tree of the Median for Subduction Source

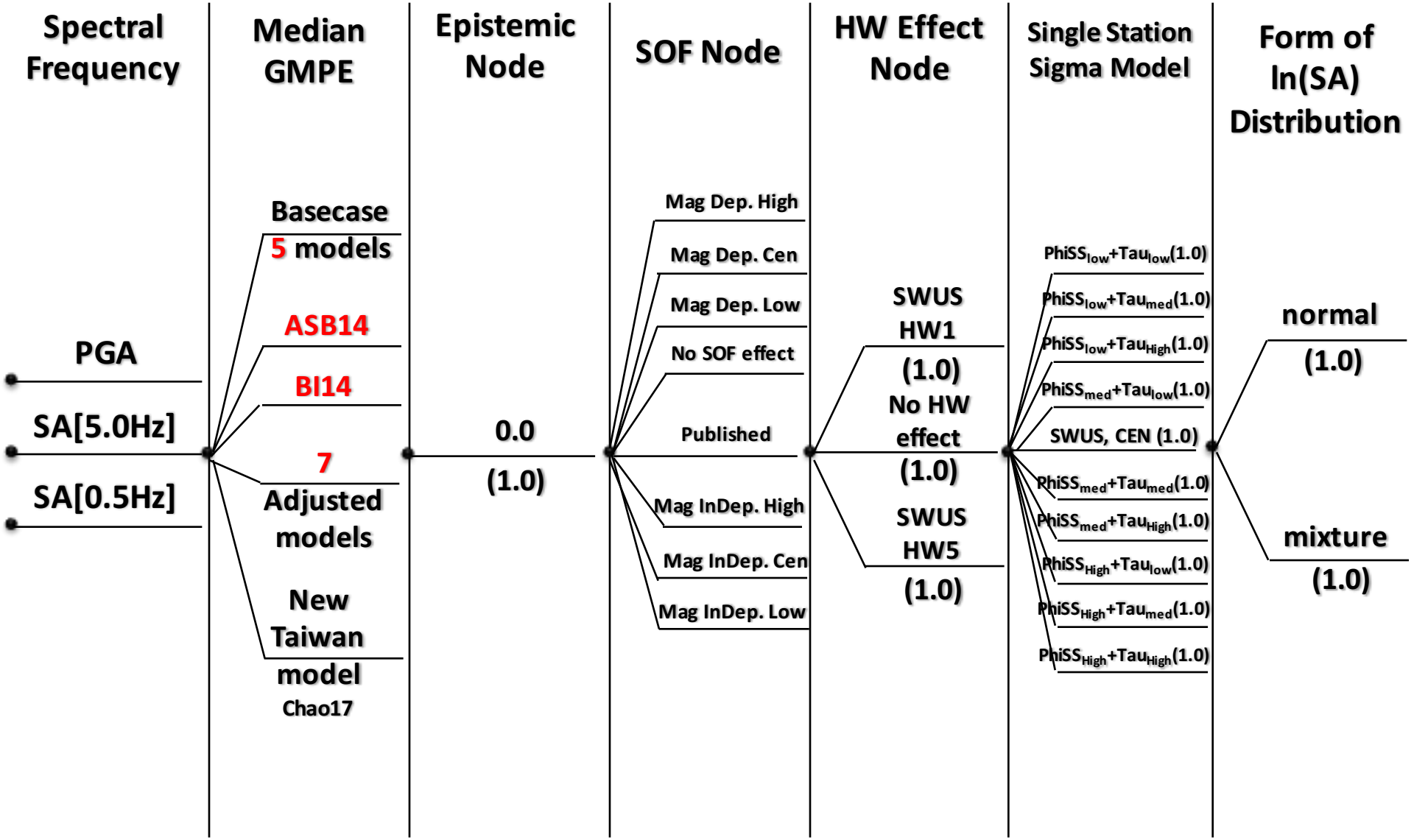


Logic Tree of the SigmaSS for Subduction Source



CRUSTAL GMC SENSITIVITY

GMC—Crustal Sensitivity case (WS#3)



Node 1: Crustal GMPE for Median

Region	Branch	GMPEs used in Sensitivity
Global model (Basecase)	1	ASK14 (Abrahamson, et al., 2014)
	2	BSSA14 (Boore et al., 2014)
	3	CB14 (Campbell and Bozorgnia, 2014)
	4	CY14 (Chiou and Youngs, 2014)
	5	I14 (Idriss, 2014)
Europe (SIGMA project models)	6	ASB14 (Akkar et al., 2014)
	7	BI14 (Bindi et al., 2014)
Adjusted model	8	ASK14_C01
	9	BSSA14_C01
	10	CB14_C01
	11	CY14_C01
	12	I14 _C01
	13	ASB14_C01
	14	BI14_C01
Taiwan new model	15	Chao17

Node 2: Style of Faulting

Branch	GMPEs	Value
1	Basecase 5 models	Published
2	Basecase 5 models	No SoF
3	Basecase 5 models	Magnitude dependent Center
4	Basecase 5 models	Magnitude dependent High
5	Basecase 5 models	Magnitude dependent Low
6	Basecase 5 models	Magnitude independent Center
7	Basecase 5 models	Magnitude independent High
8	Basecase 5 models	Magnitude independent Low

Node 3: Hanging-wall effect

Branch	GMPEs	Value
1	Basecase 5 models	Published
1	Basecase 5 models	No Hanging-wall effect
2	Basecase 5 models	SWUS HW Model 1
3	Basecase 5 models	SWUS HW Model 5

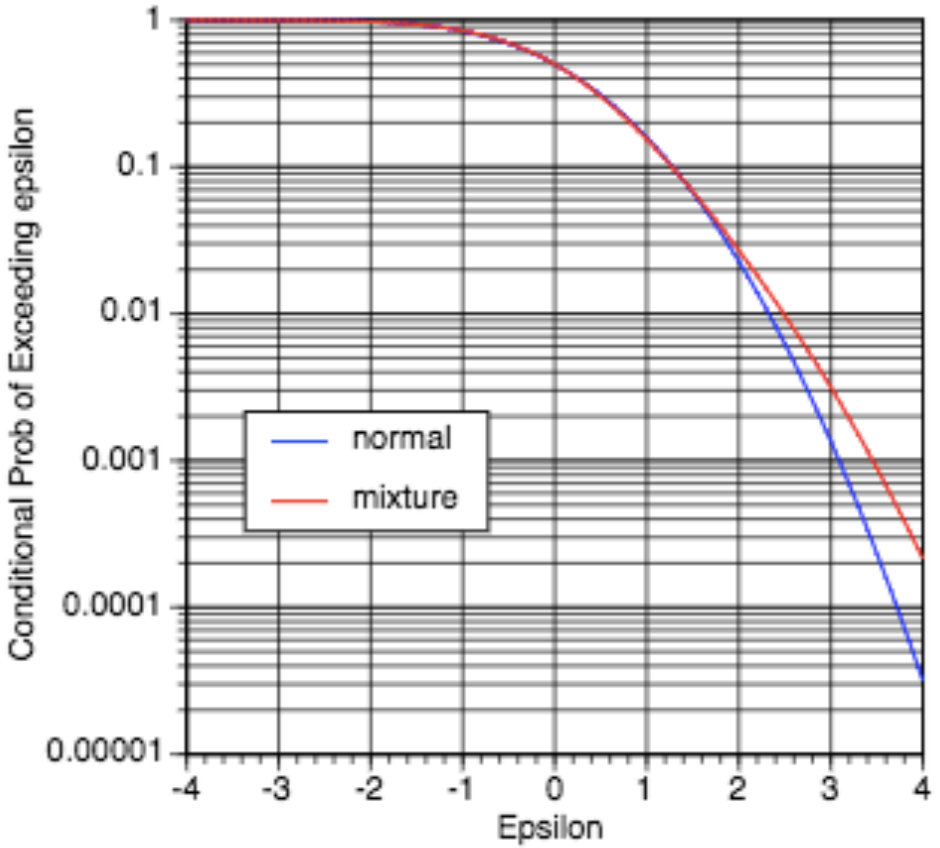
Node 4: Crustal SigmaSS

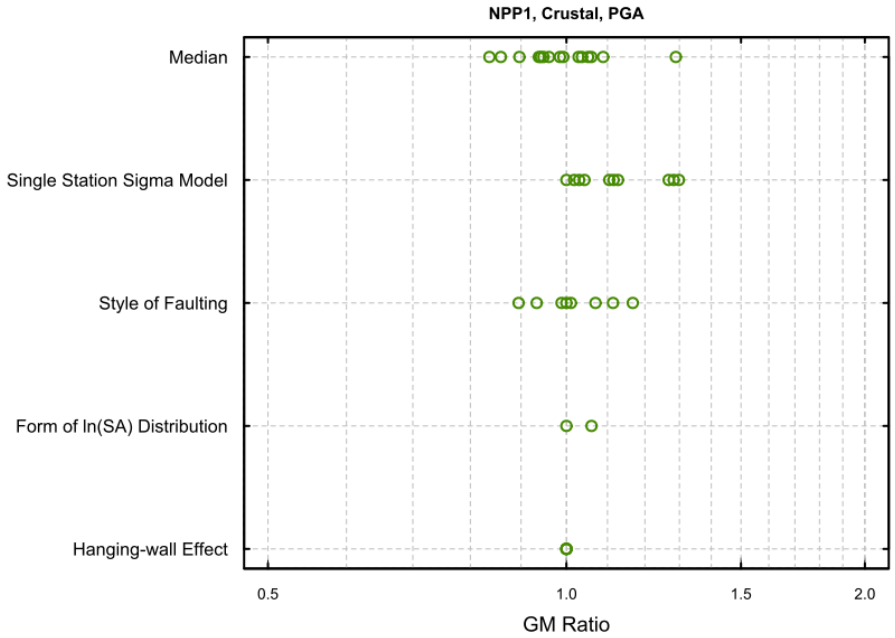
- **Use the 3 Taiwan Magnitude Independent Phi_SS models with the 3 Global Magnitude dependent tau models (9 total).**

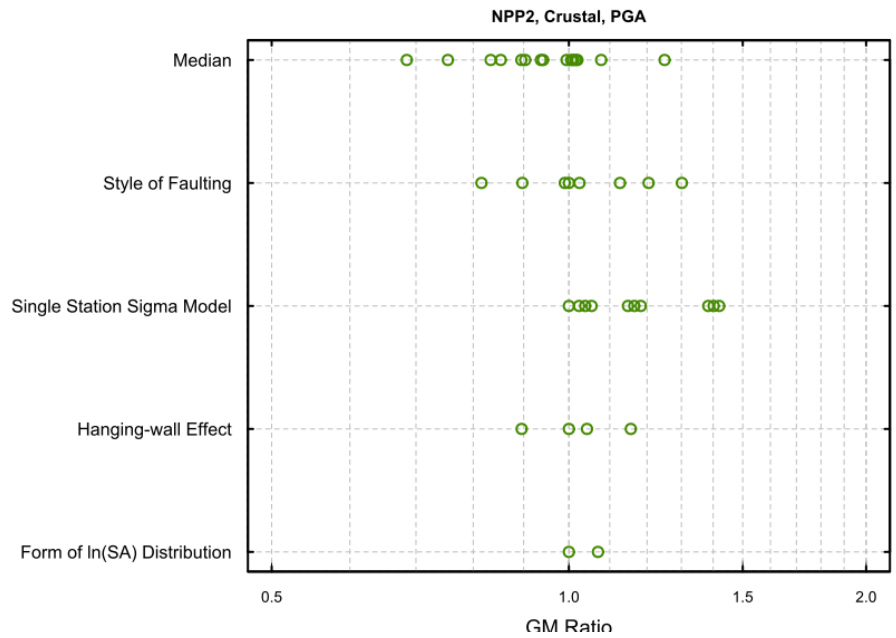
Branch	Value
1	Taiwan phiSS low & global tau low
2	Taiwan phiSS low & global tau med
3	Taiwan phiSS low & global tau high
4	Taiwan phiSS med & global tau low
5	Taiwan phiSS med & global tau med
6	Taiwan phiSS med & global tau high
7	Taiwan phiSS high & global tau low
8	Taiwan phiSS high & global tau med
9	Taiwan phiSS high & global tau high

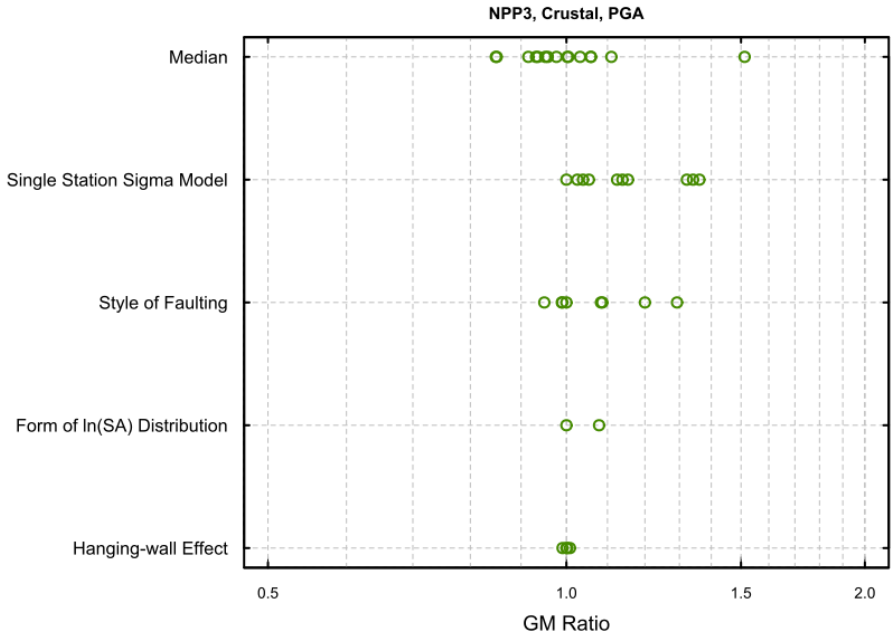
Node 5: Crustal Form of Distribution of ln(SA)

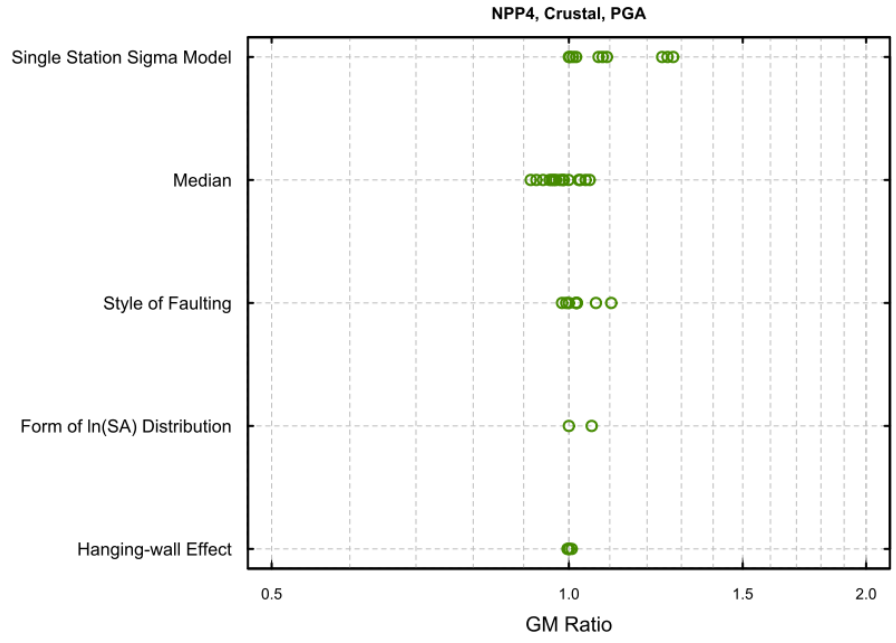
Branch	Value
1	Normal Distribution
2	SWUS Mixture Model

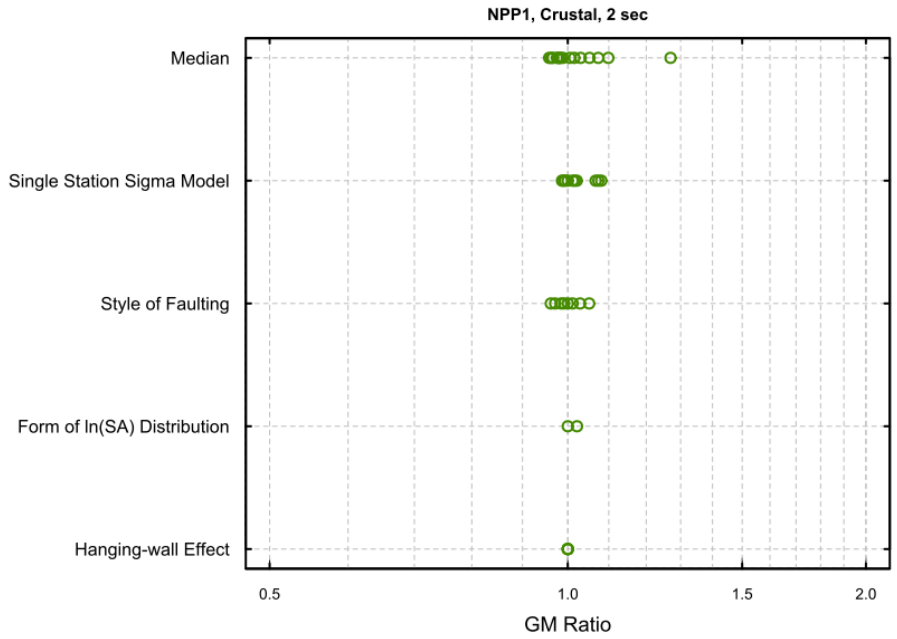


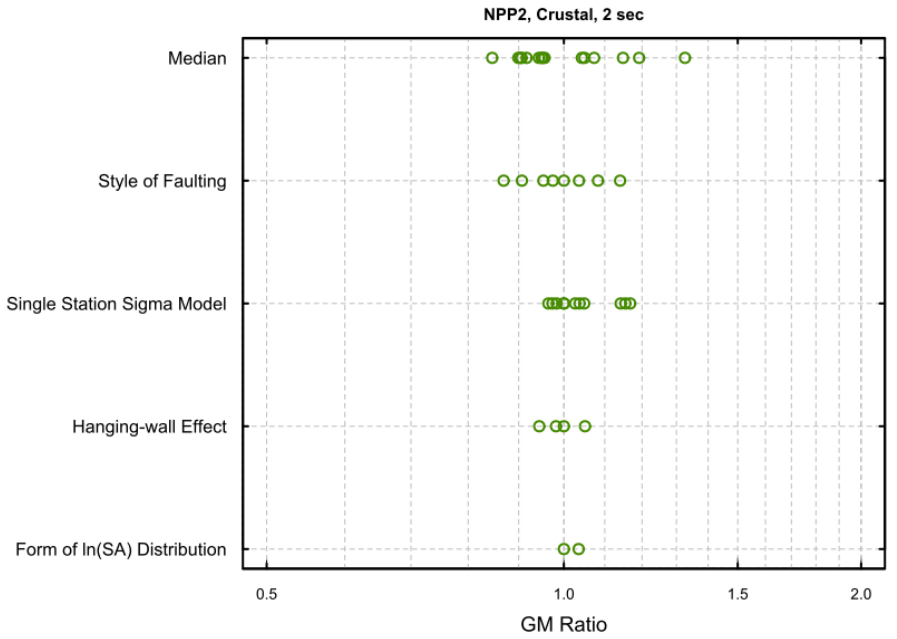

NPP1, Crustal, PGA
Median
Single Station Sigma Model
Style of Faulting
Form of ln(SA) Distribution
Hanging-wall Effect
0.5
1.0
1.5
2.0
GM Ratio

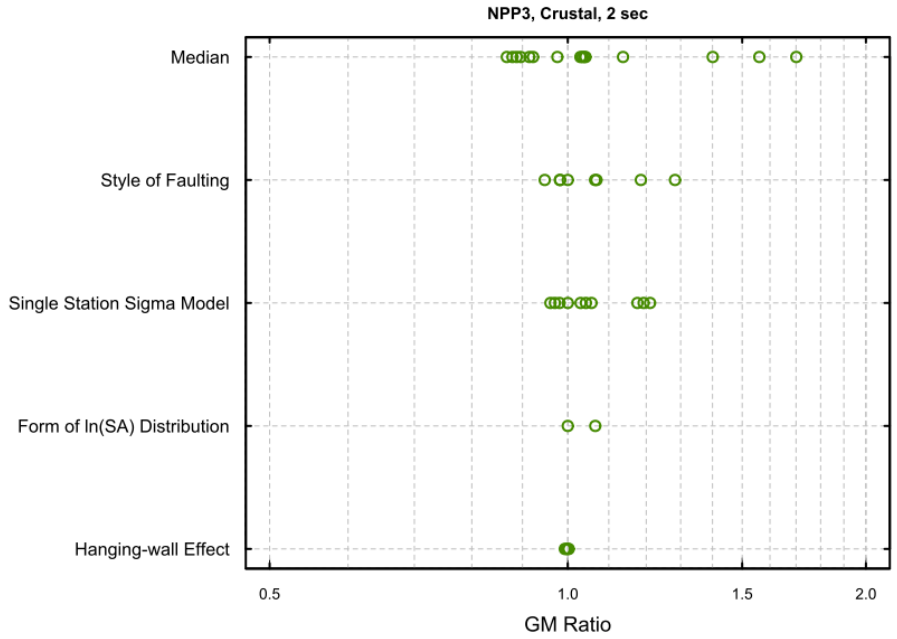

NPP2, Crustal, PGA
Median
Style of Faulting
Single Station Sigma Model
Hanging-wall Effect
Form of ln(SA) Distribution
0.5
1.0
1.5
2.0
GM Ratio

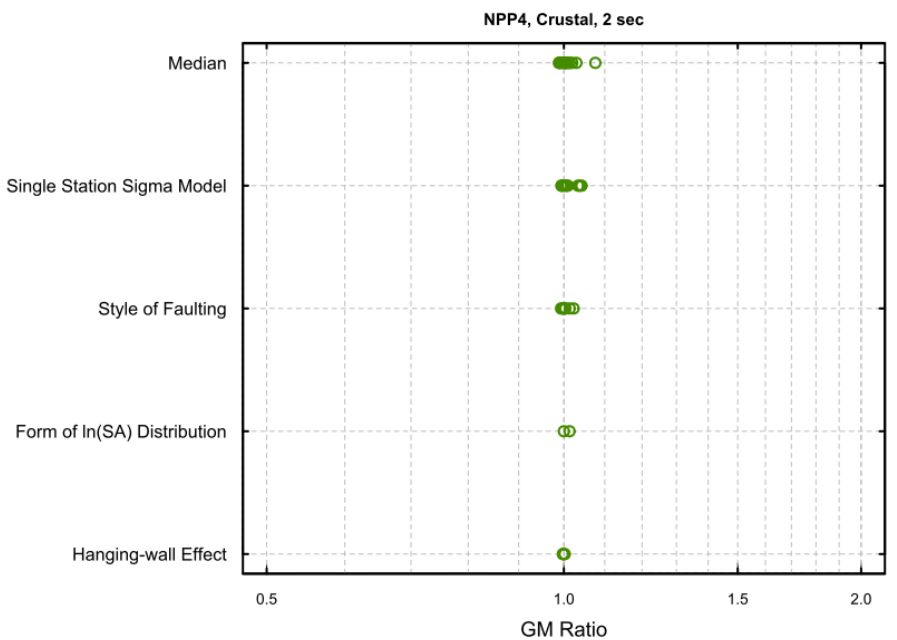

NPP3, Crustal, PGA
Median
Single Station Sigma Model
Style of Faulting
Form of ln(SA) Distribution
Hanging-wall Effect
0.5
1.0
1.5
2.0
GM Ratio


NPP4, Crustal, PGA
Single Station Sigma Model
Median
Style of Faulting
Form of ln(SA) Distribution
Hanging-wall Effect
0.5
1.0
1.5
2.0
GM Ratio


NPP1, Crustal, 2 sec
Median
Single Station Sigma Model
Style of Faulting
Form of ln(SA) Distribution
Hanging-wall Effect
0.5
1.0
1.5
2.0
GM Ratio

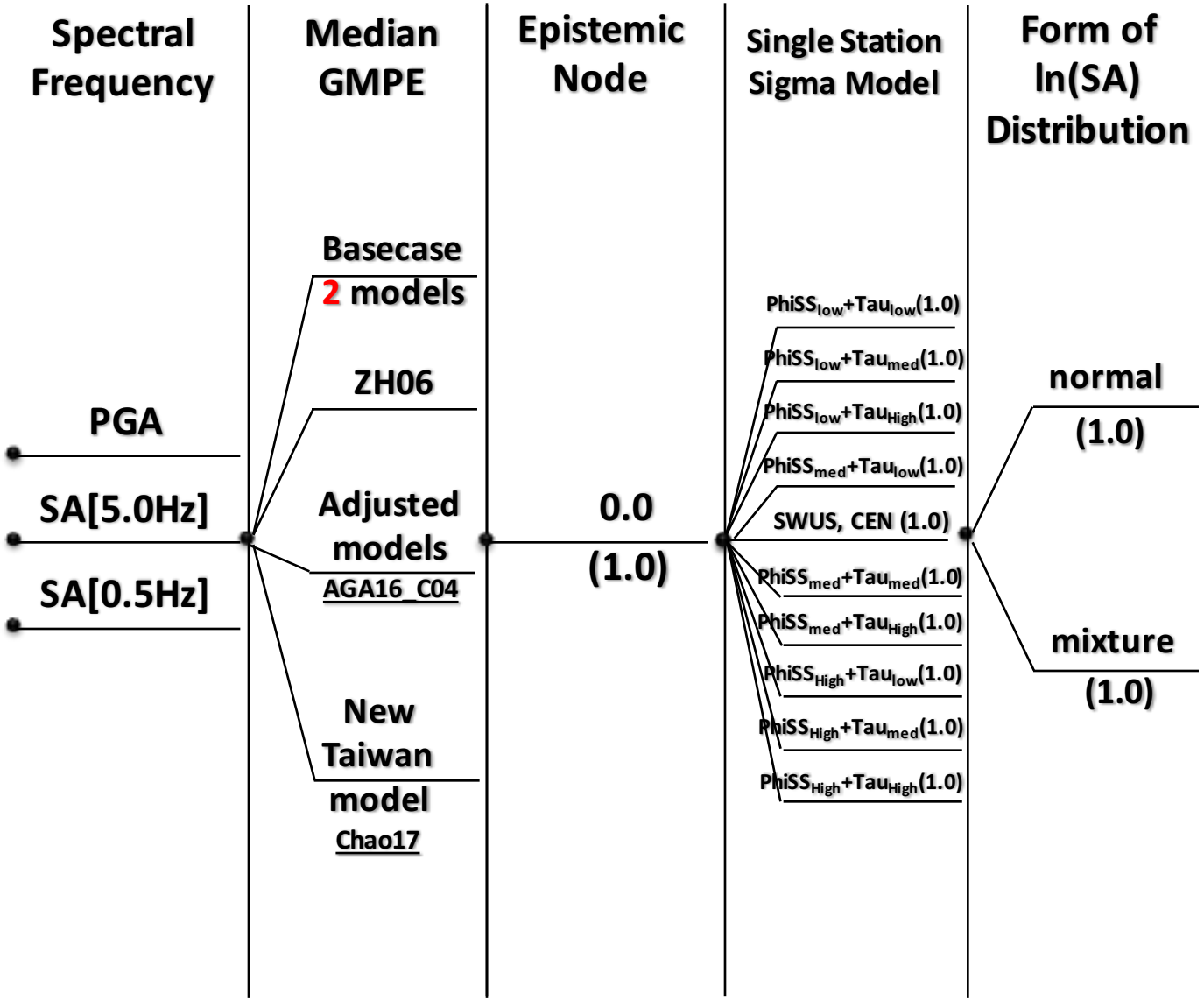

NPP2, Crustal, 2 sec
Median
Style of Faulting
Single Station Sigma Model
Hanging-wall Effect
Form of ln(SA) Distribution
0.5
1.0
1.5
2.0
GM Ratio


NPP3, Crustal, 2 sec
Median
Style of Faulting
Single Station Sigma Model
Form of ln(SA) Distribution
Hanging-wall Effect
0.5
1.0
1.5
2.0
GM Ratio


NPP4, Crustal, 2 sec
Median
Single Station Sigma Model
Style of Faulting
Form of ln(SA) Distribution
Hanging-wall Effect
0.5
1.0
1.5
2.0
GM Ratio

SUBDUCTION GMC SENSITIVITY

GMC—Subduction Sensitivity case (WS#3)



Node 1: Subduction GMPE for Median

Region	Branch	GMPEs used in Sensitivity
Global	1	BCH (BCHydro, 2016)
Taiwan	2	LL08 (Lin and Lee, 2008)
Japan	3	ZH06 (Zhao et al., 2006)
Taiwan new model	4	Chao17
Adjusted model	5	AGA16_C04

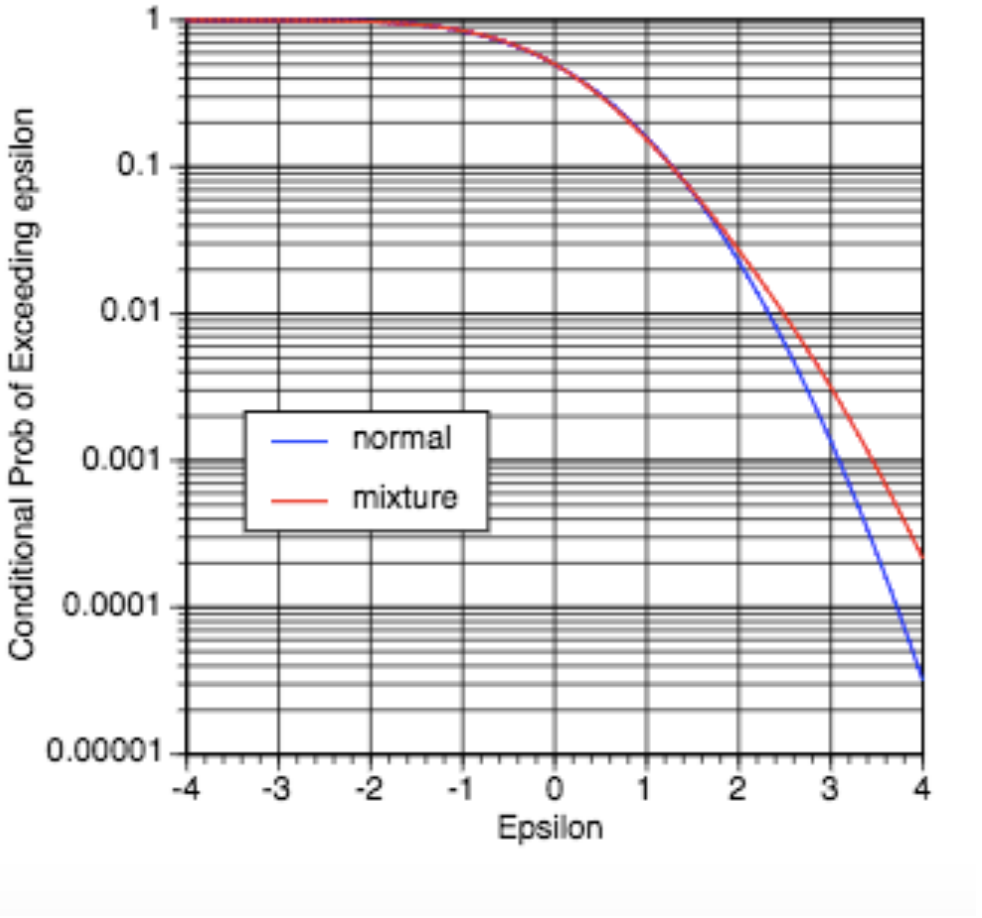
Node 2: Subduction SigmaSS

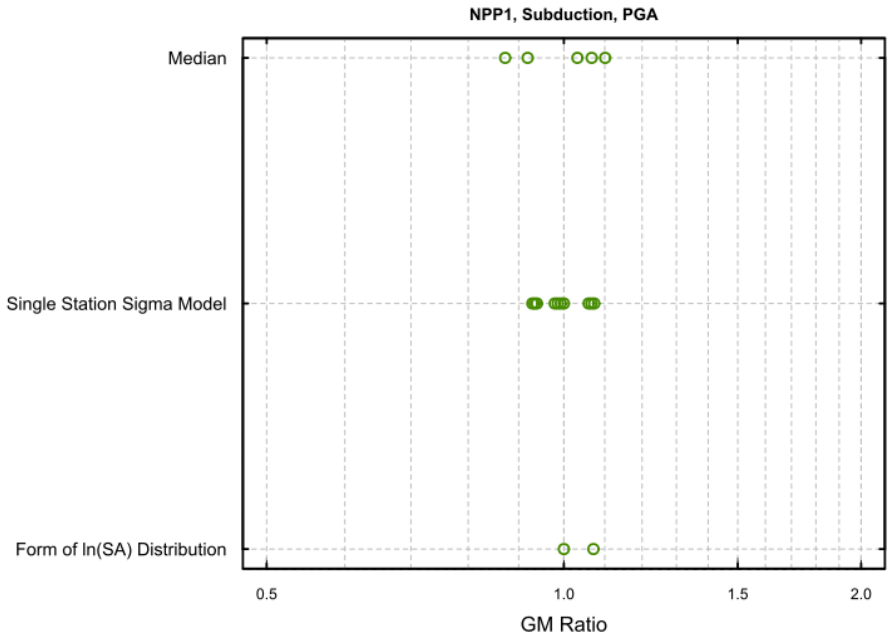
- **Use the 3 Taiwan Magnitude Independent Phi_SS models with the 3 Global Magnitude independent tau models (9 total).**

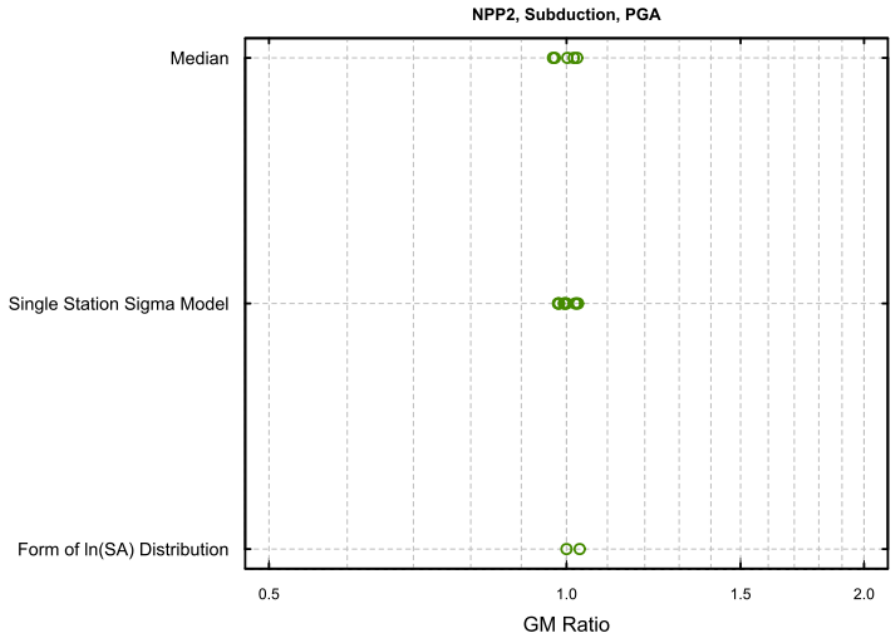
Branch	Value
1	Taiwan phiSS low & global tau low
2	Taiwan phiSS low & global tau med
3	Taiwan phiSS low & global tau high
4	Taiwan phiSS med & global tau low
5	Taiwan phiSS med & global tau med
6	Taiwan phiSS med & global tau high
7	Taiwan phiSS high & global tau low
8	Taiwan phiSS high & global tau med
9	Taiwan phiSS high & global tau high

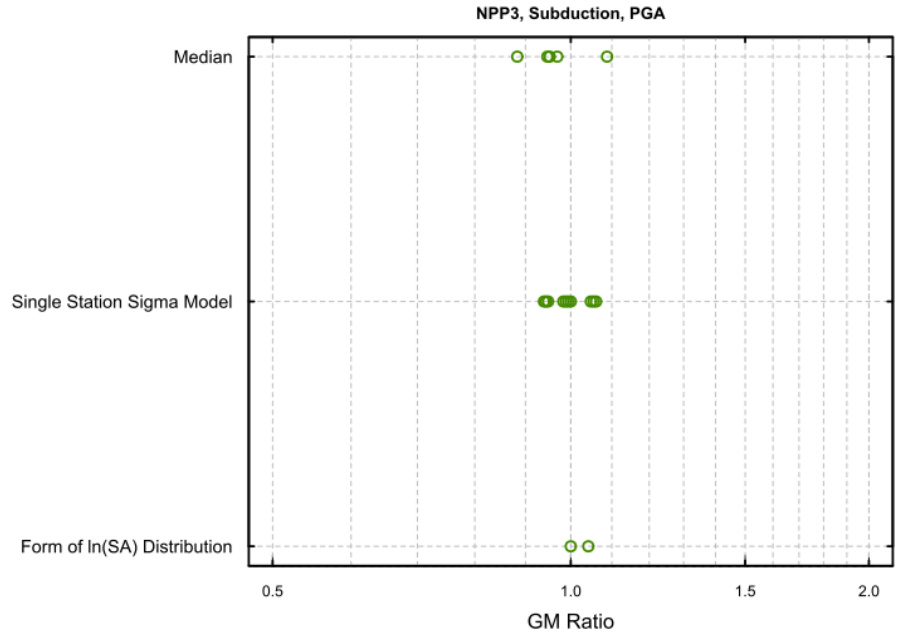
Node 3: Subduction Form of Distribution of ln(SA)

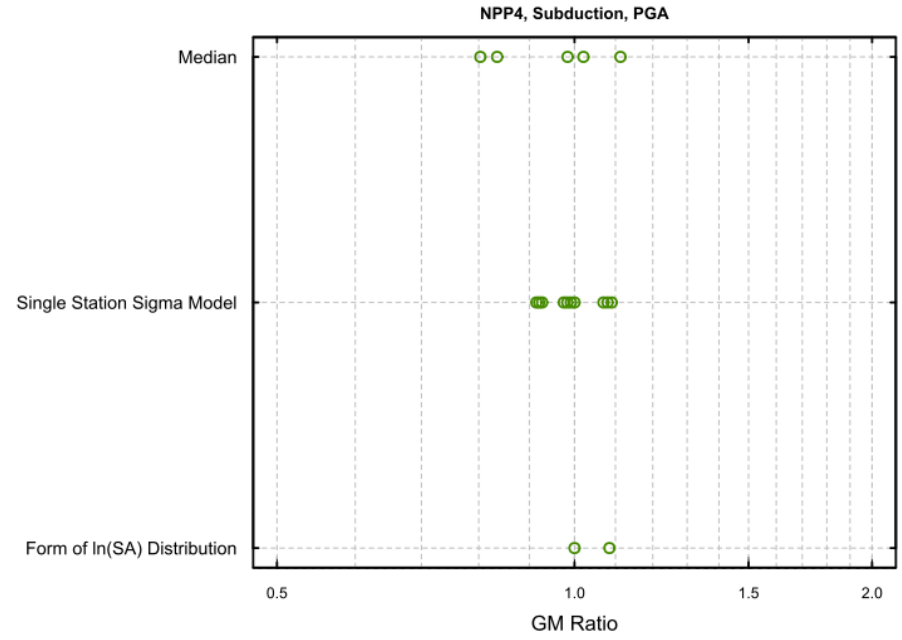
Branch	Value
1	Normal Distribution
2	SWUS Mixture Model

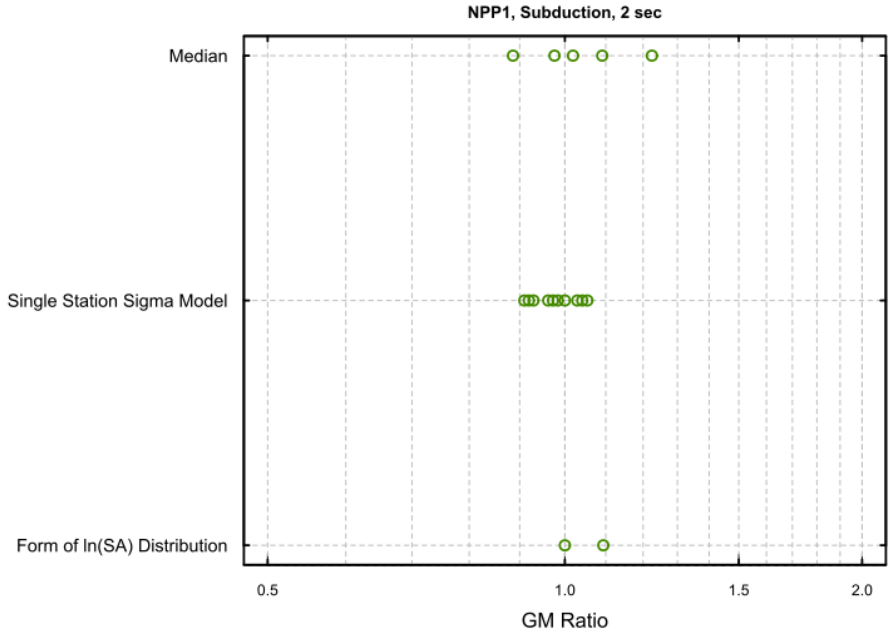


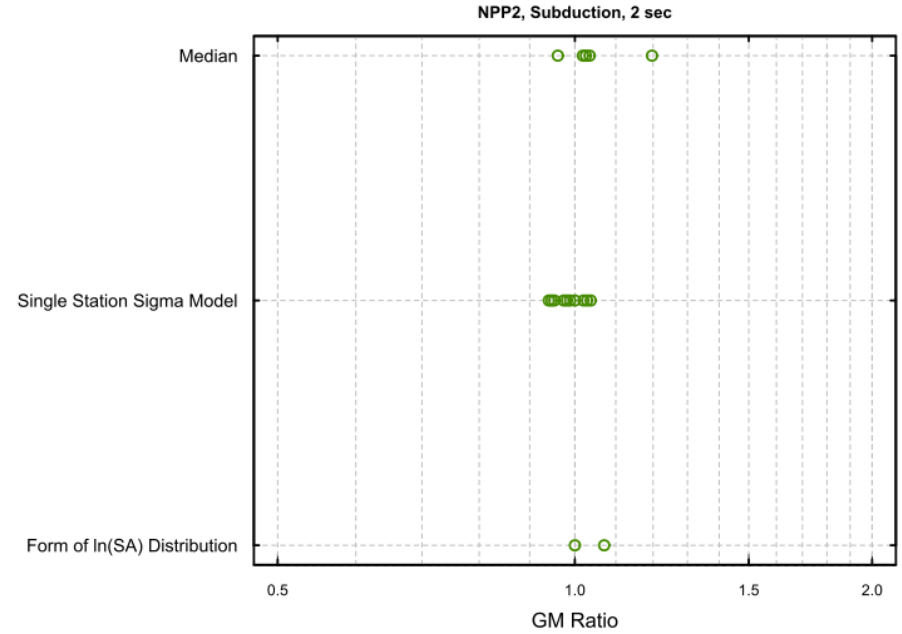

NPP1, Subduction, PGA
Median
Single Station Sigma Model
Form of ln(SA) Distribution
0.5
1.0
1.5
2.0
GM Ratio

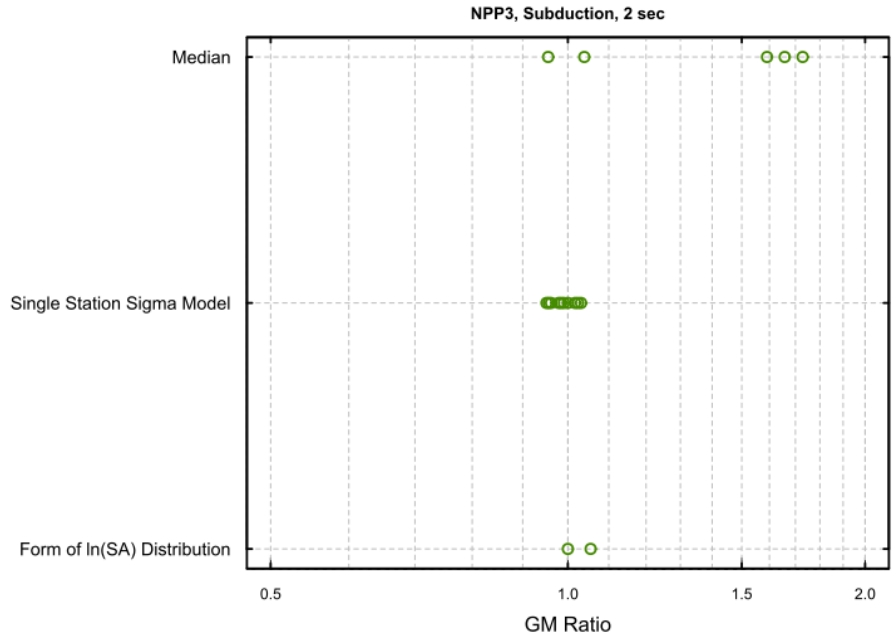

NPP2, Subduction, PGA
Median
Single Station Sigma Model
Form of ln(SA) Distribution
0.5
1.0
1.5
2.0
GM Ratio

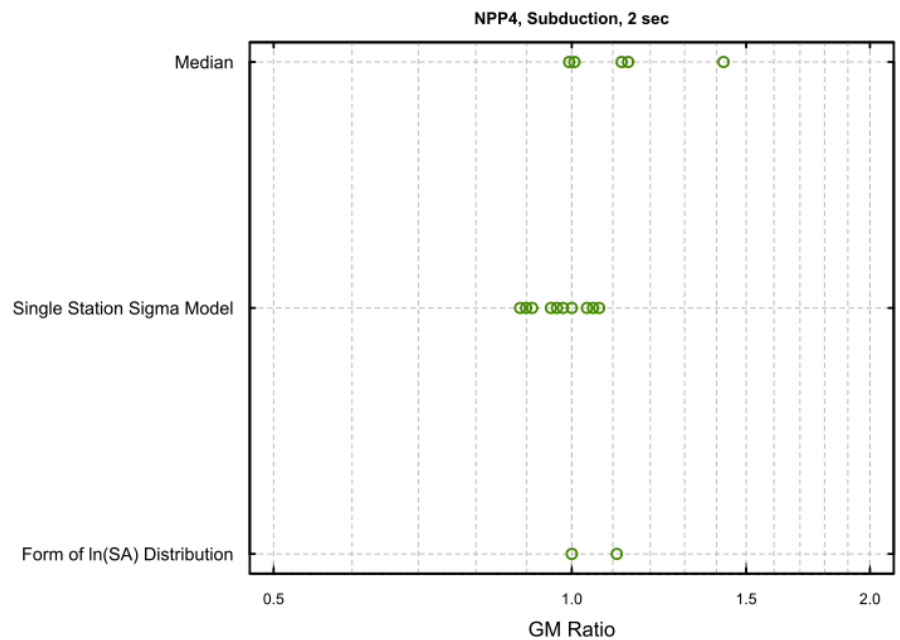

NPP3, Subduction, PGA
Median
Single Station Sigma Model
Form of ln(SA) Distribution
0.5
1.0
1.5
2.0
GM Ratio


NPP4, Subduction, PGA
Median
Single Station Sigma Model
Form of ln(SA) Distribution
0.5
1.0
1.5
2.0
GM Ratio


NPP1, Subduction, 2 sec
Median
Single Station Sigma Model
Form of ln(SA) Distribution
0.5
1.0
1.5
2.0
GM Ratio


NPP2, Subduction, 2 sec
Median
Single Station Sigma Model
Form of ln(SA) Distribution
0.5
1.0
1.5
2.0
GM Ratio

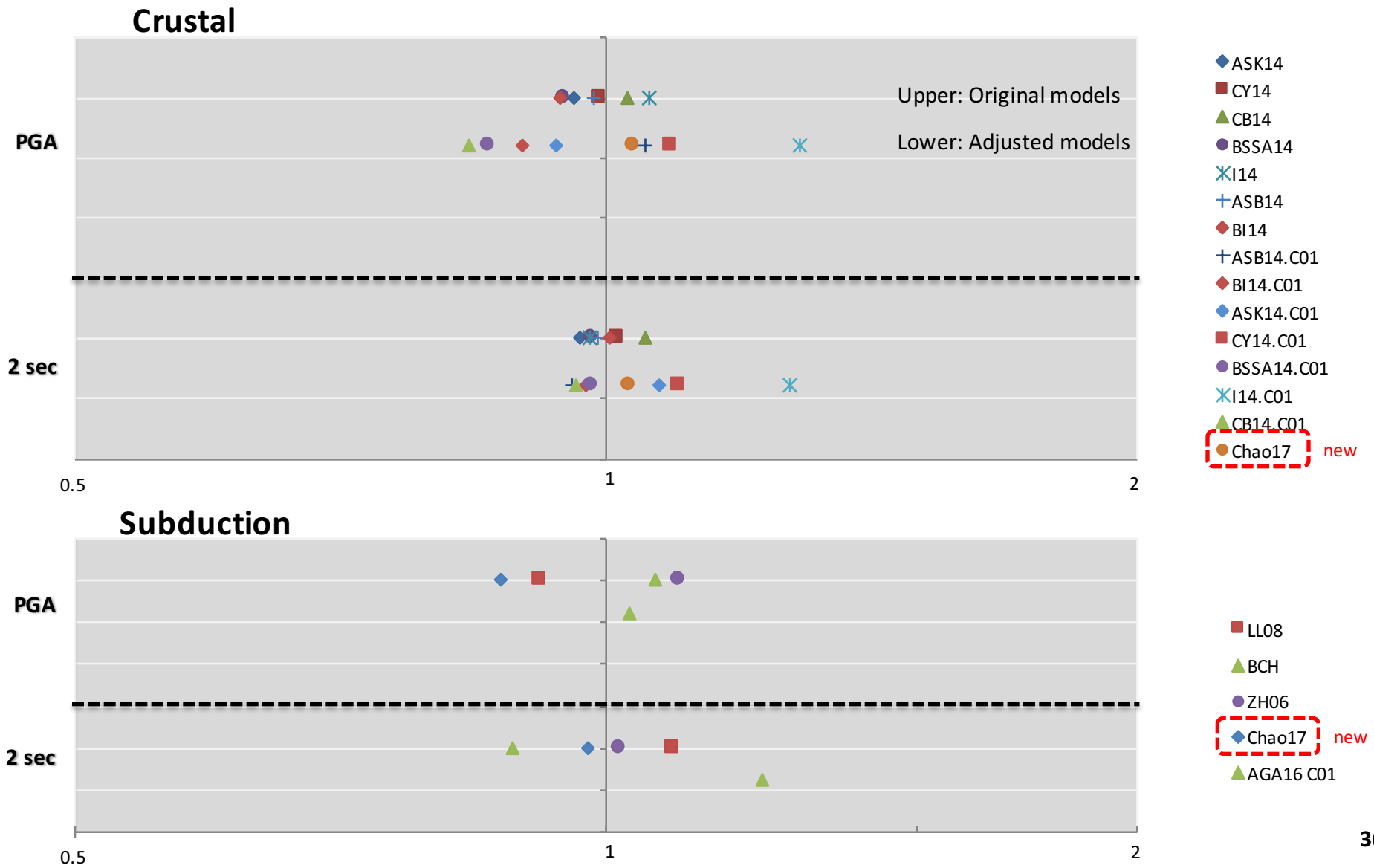

NPP3, Subduction, 2 sec
Median
Single Station Sigma Model
Form of ln(SA) Distribution
0.5
1.0
1.5
2.0
GM Ratio


NPP4, Subduction, 2 sec
Median
Single Station Sigma Model
Form of ln(SA) Distribution
0.5
1.0
1.5
2.0
GM Ratio

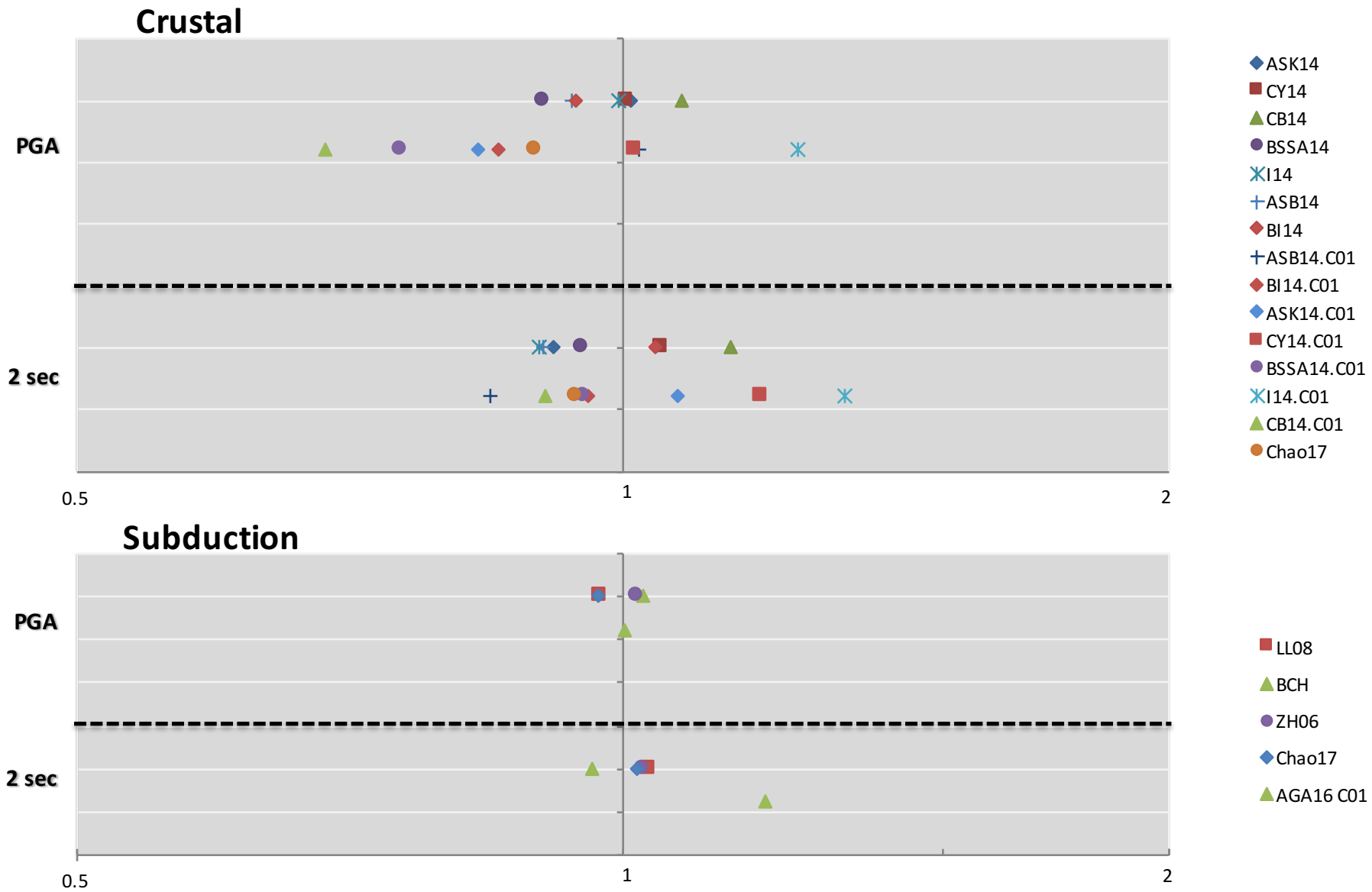
For Adjusted Models - median

GMC SENSITIVITY RESULTS

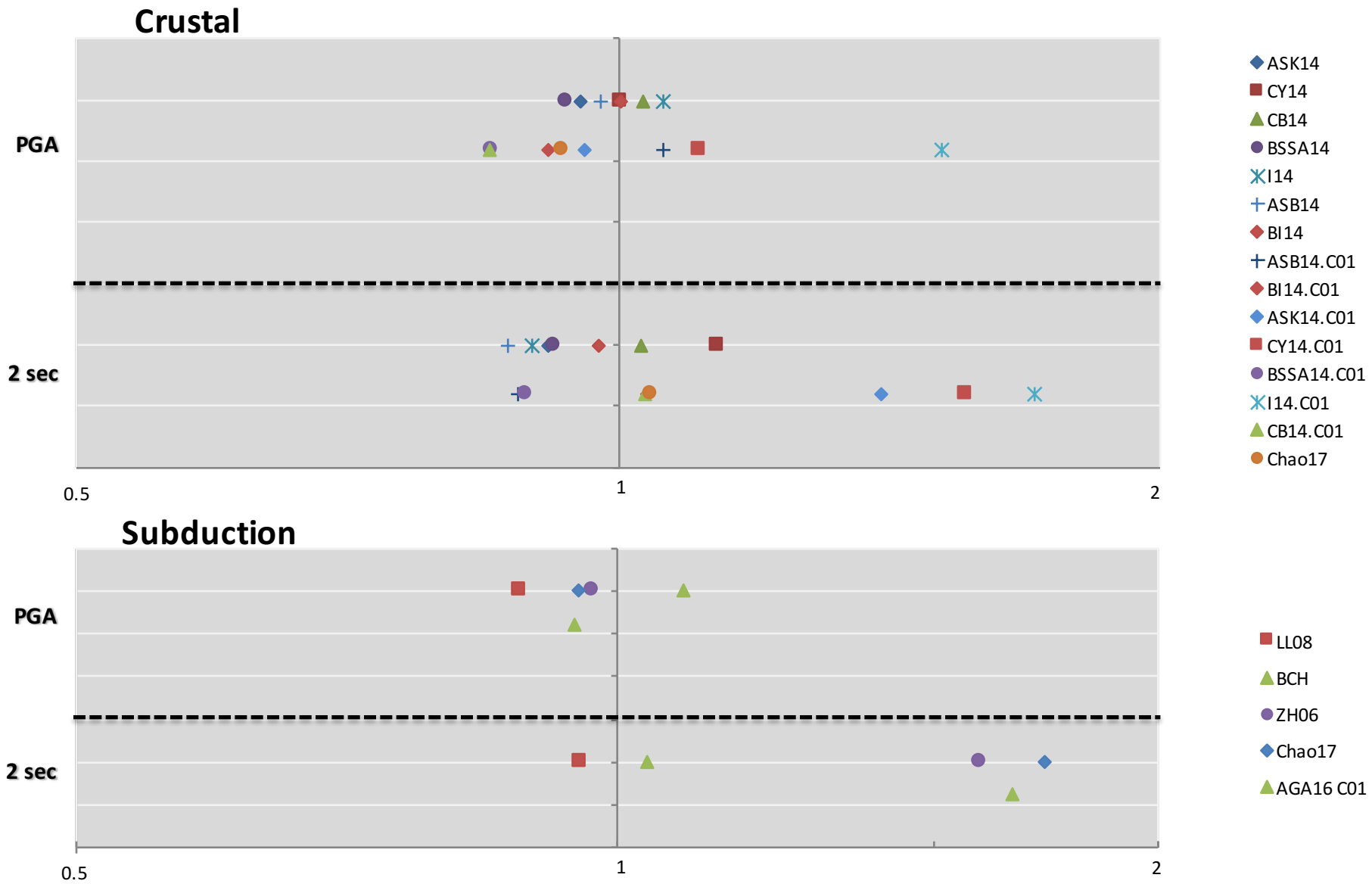
NPP1


Crustal
PGA
2 sec
Upper: Original models
Lower: Adjusted models
0.5
1
2
ASK14
CY14
CB14
BSSA14
I14
ASB14
BI14
ASB14.C01
BI14.C01
ASK14.C01
CY14.C01
BSSA14.C01
I14.C01
CB14.C01
Chao17
new
Subduction
PGA
2 sec
0.5
1
2
LL08
BCH
ZH06
Chao17
new
AGA16 C01

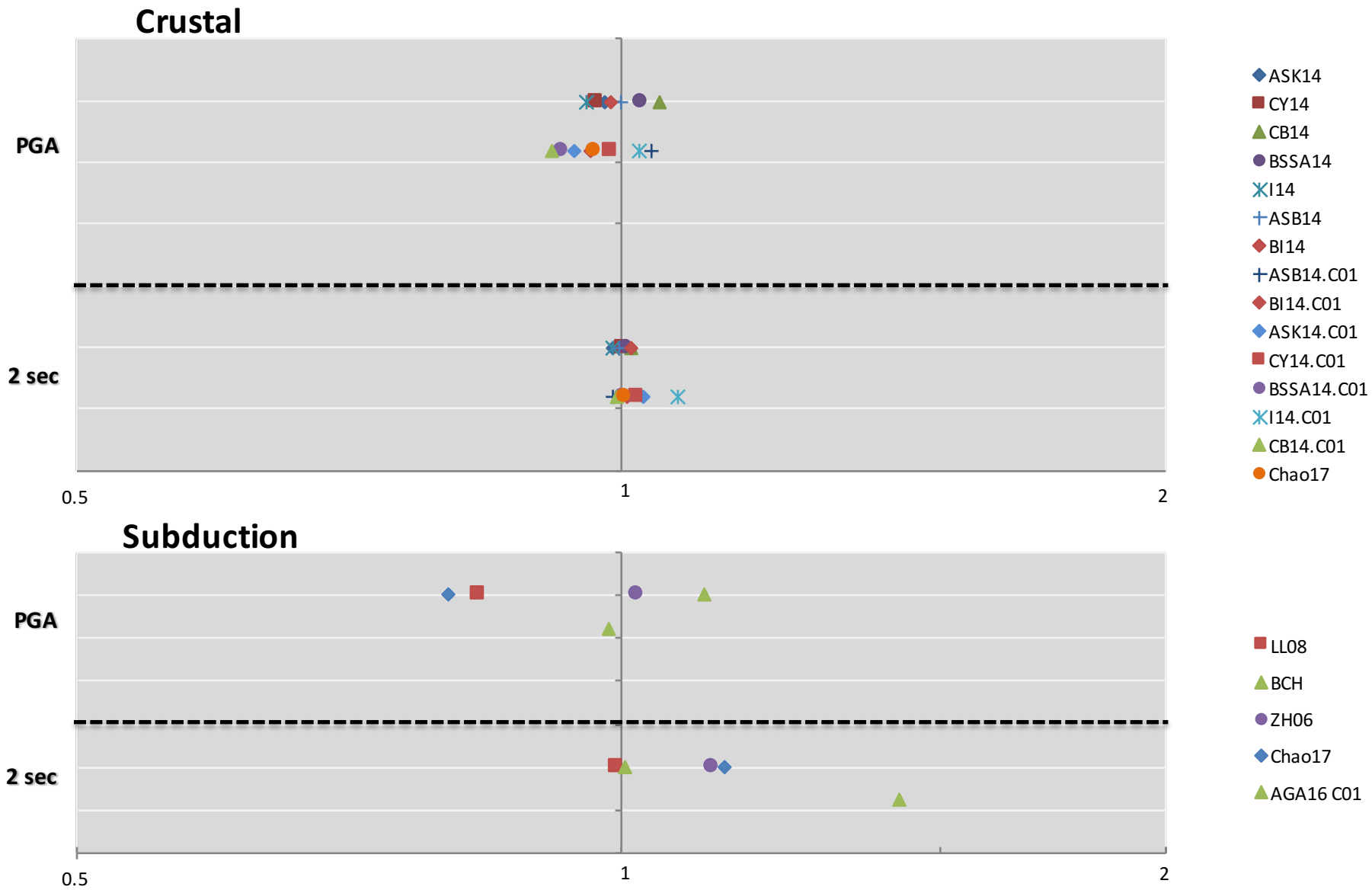
NPP2


Crustal
PGA
2 sec
0.5
1
2
ASK14
CY14
CB14
BSSA14
I14
ASB14
BI14
ASB14.C01
BI14.C01
ASK14.C01
CY14.C01
BSSA14.C01
I14.C01
CB14.C01
Chao17
Subduction
PGA
2 sec
0.5
1
2
LL08
BCH
ZH06
Chao17
AGA16 C01

NPP3


Crustal
PGA
2 sec
0.5
1
2
ASK14
CY14
CB14
BSSA14
I14
ASB14
BI14
ASB14.C01
BI14.C01
ASK14.C01
CY14.C01
BSSA14.C01
I14.C01
CB14.C01
Chao17
Subduction
PGA
2 sec
0.5
1
2
LL08
BCH
ZH06
Chao17
AGA16 C01

NPP4

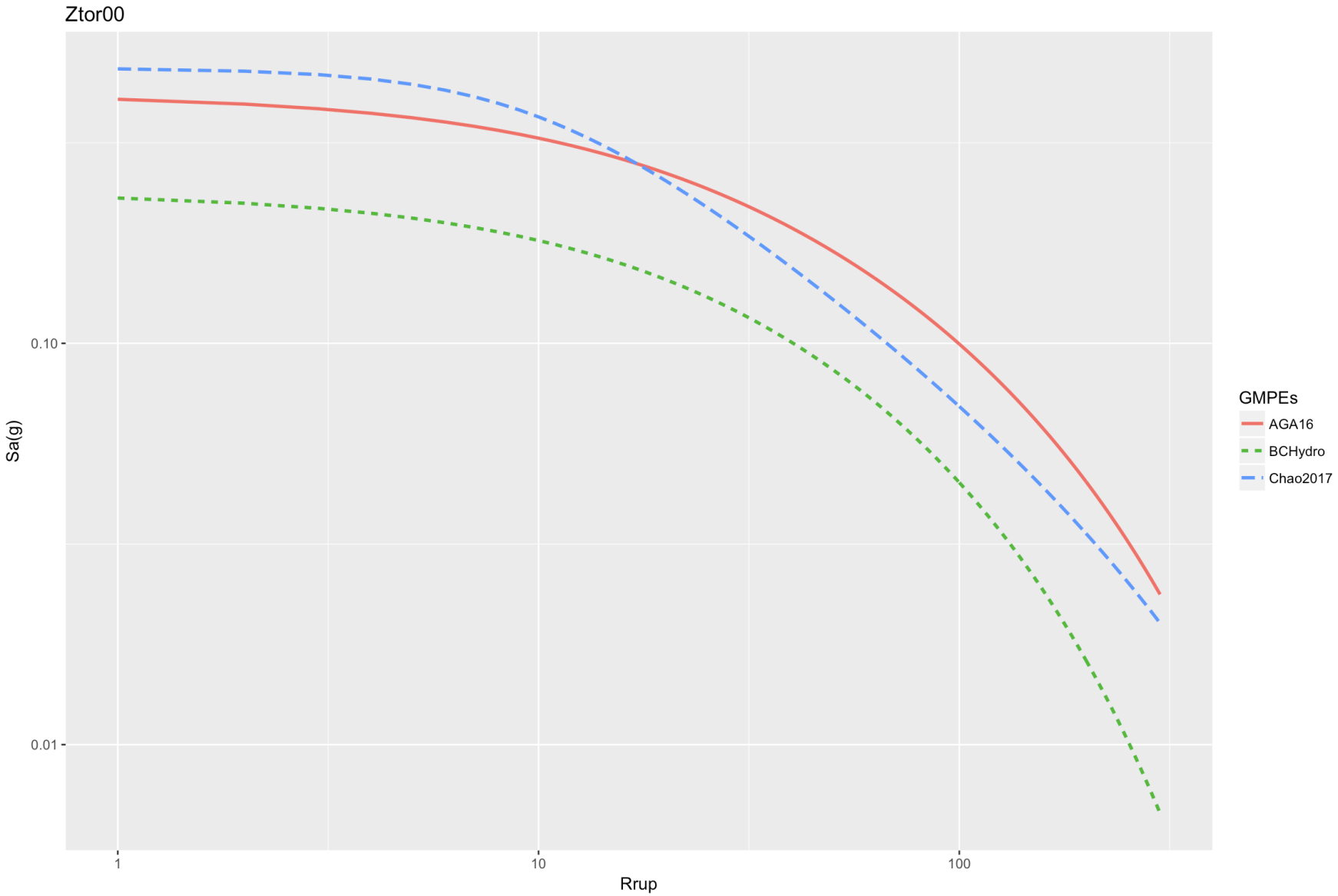

Crustal
PGA
2 sec
0.5
1
2
ASK14
CY14
CB14
BSSA14
I14
ASB14
BI14
ASB14.C01
BI14.C01
ASK14.C01
CY14.C01
BSSA14.C01
I14.C01
CB14.C01
Chao17
Subduction
PGA
2 sec
0.5
1
2
LL08
BCH
ZH06
Chao17
AGA16 C01

Thank you!

BACKUP

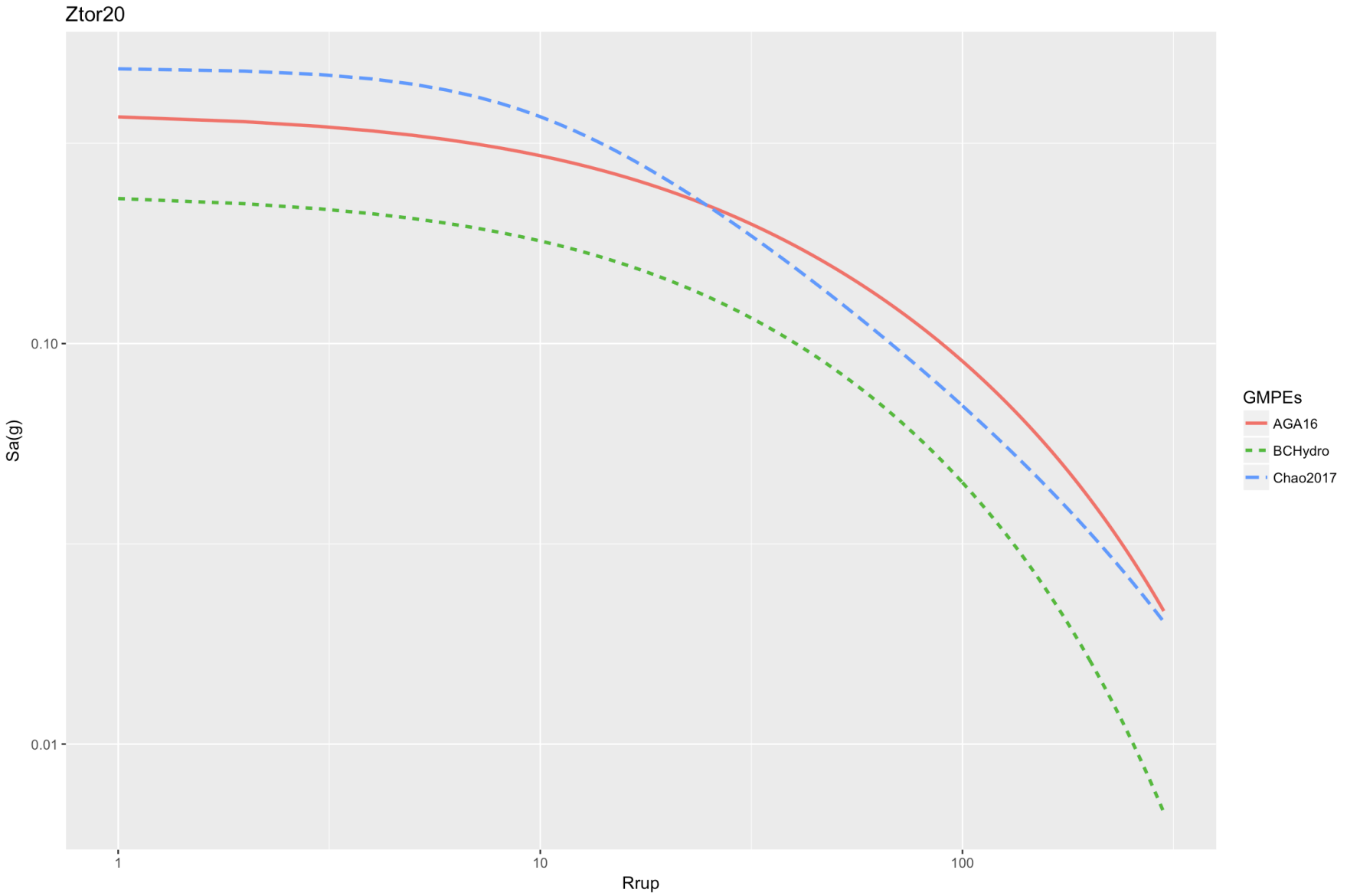
Interface, plot for distance scaling

Ztor = depth = 0 km, Mag = 8.4



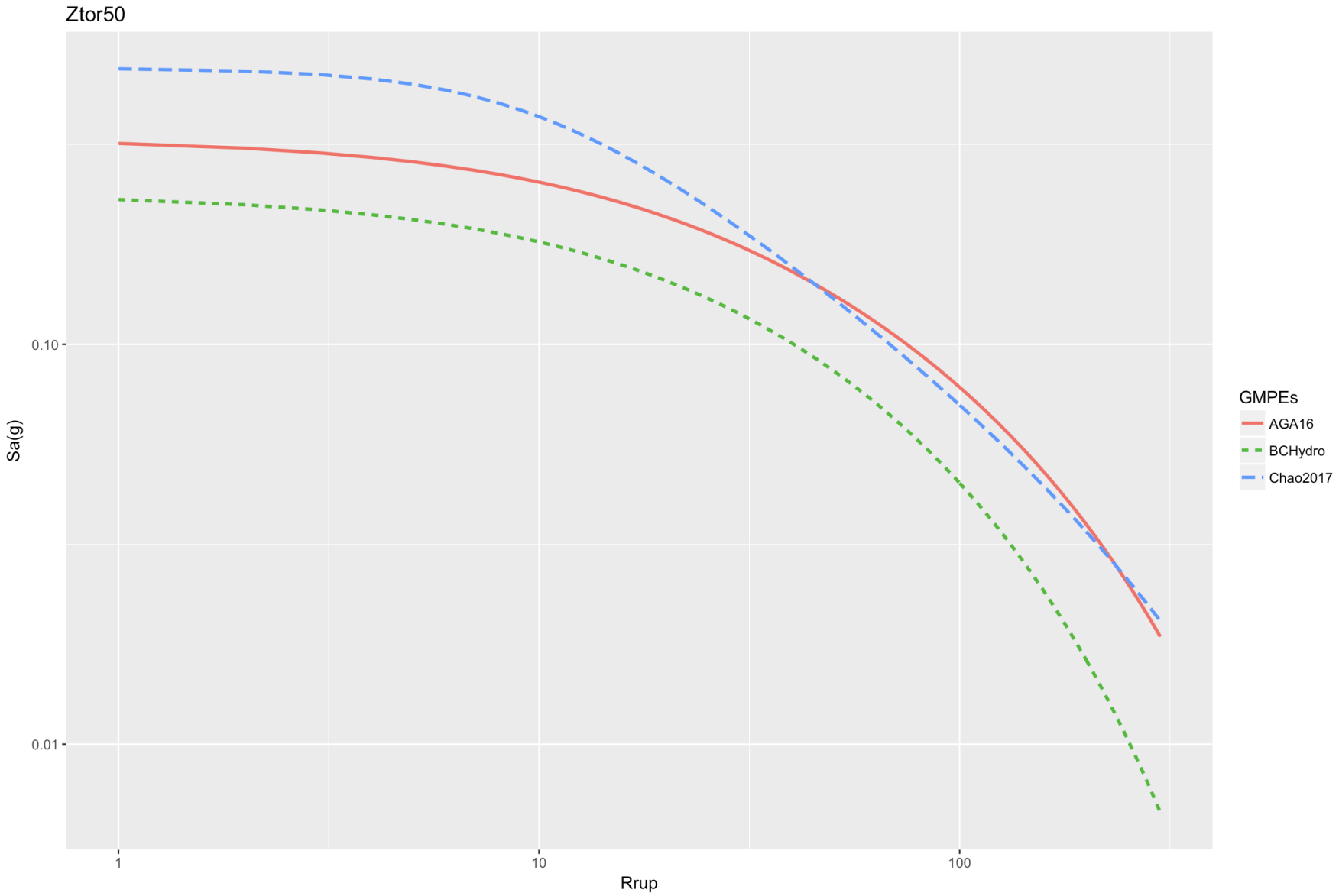
Interface, plot for distance scaling

Ztor = depth = 20 km, Mag = 8.4



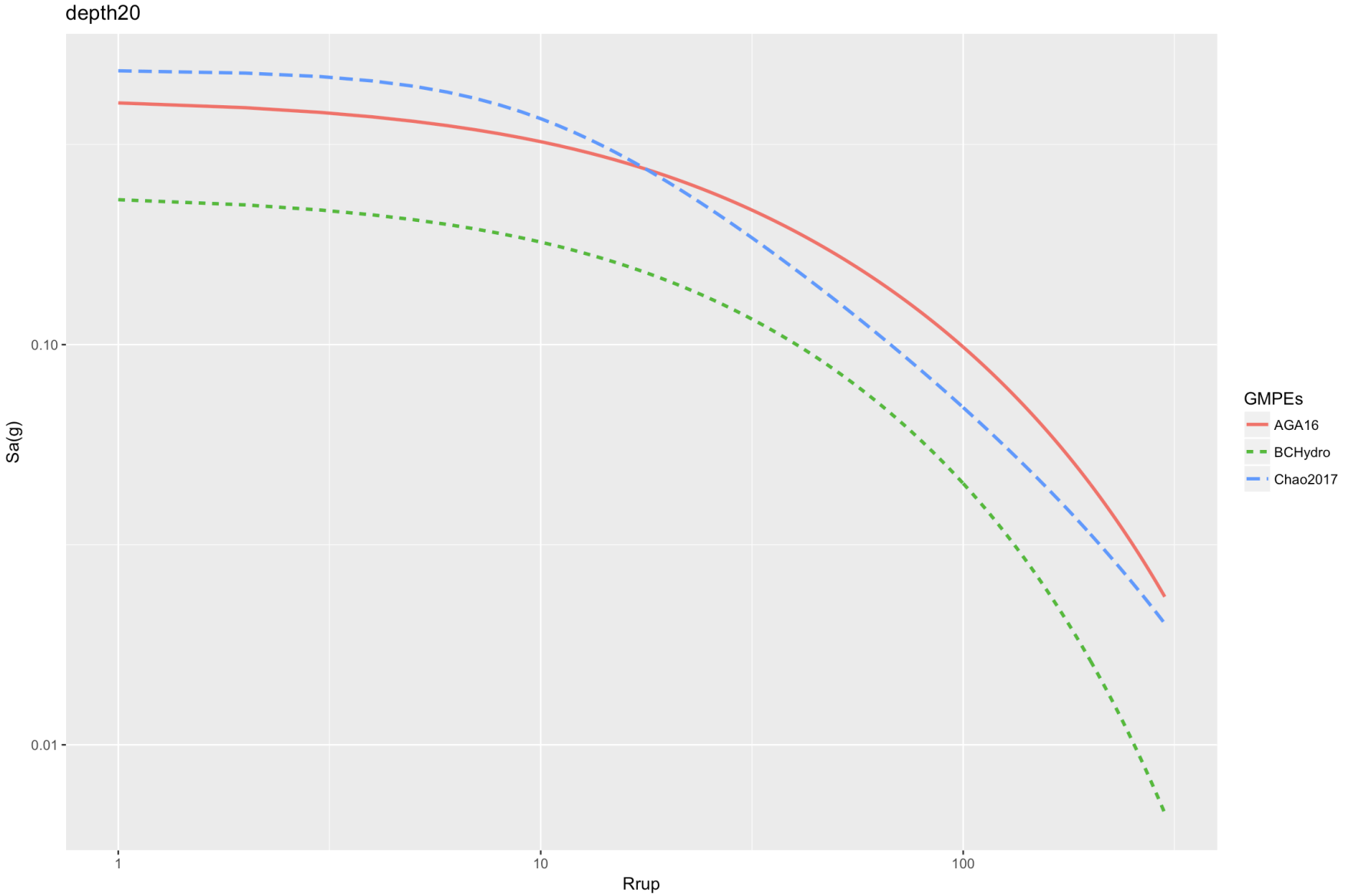
Interface, plot for distance scaling

Ztor = depth = 50 km, Mag = 8.4



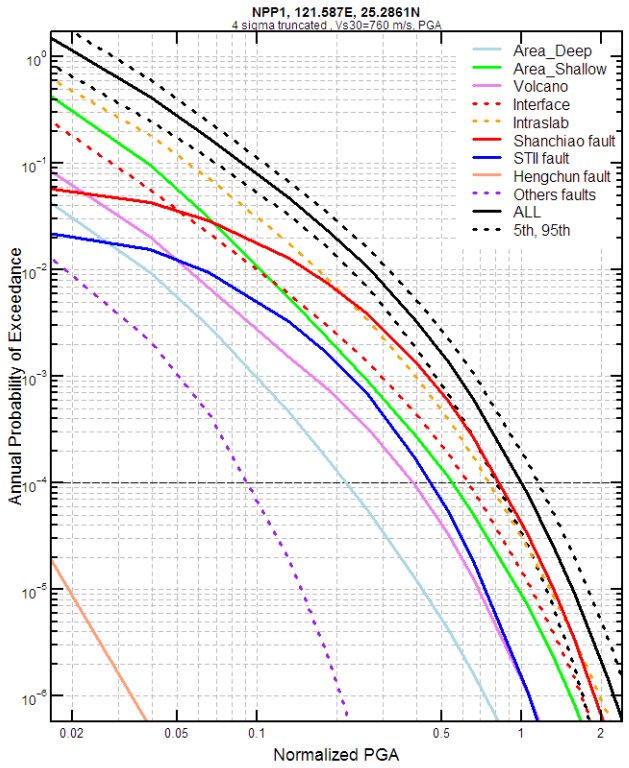
Interface, plot for distance scaling

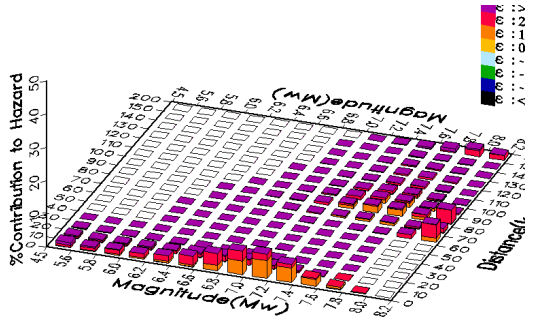
Ztor = 2, depth = 20 km, Mag = 8.4



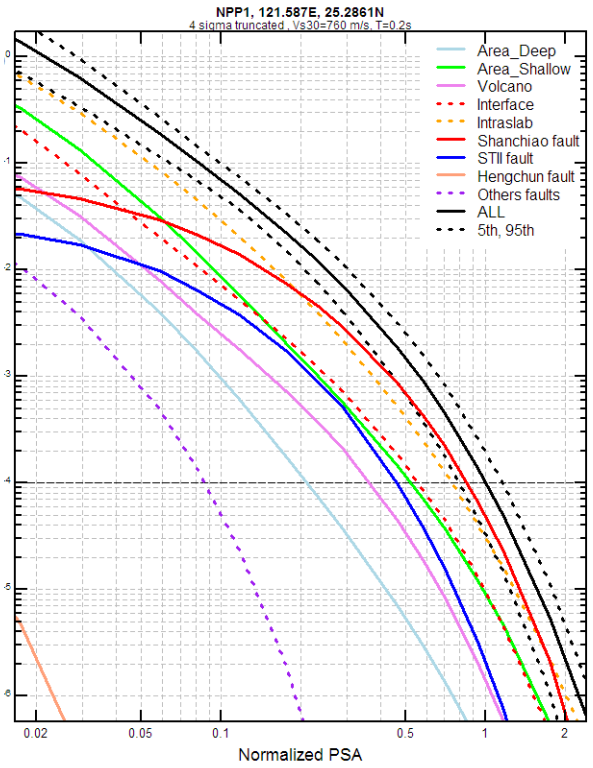
NPP1 - PGA - 5Hz – 0.5Hz

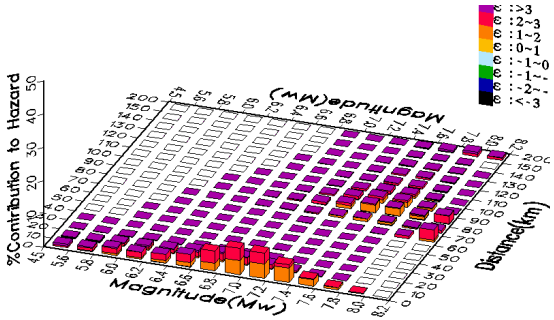
PGA



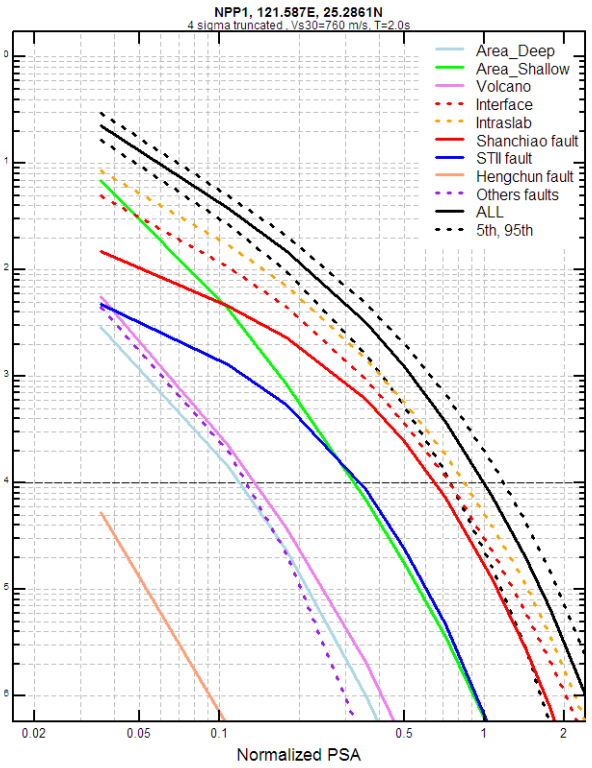


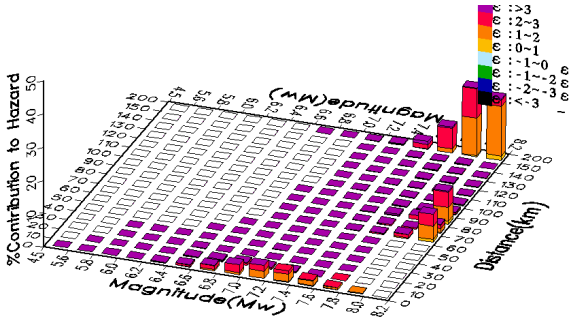
0.2s





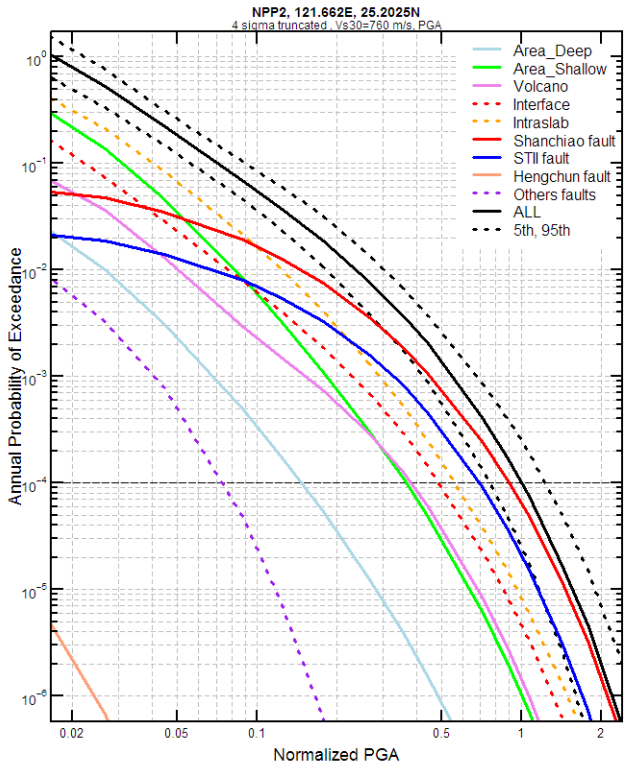
2.0s

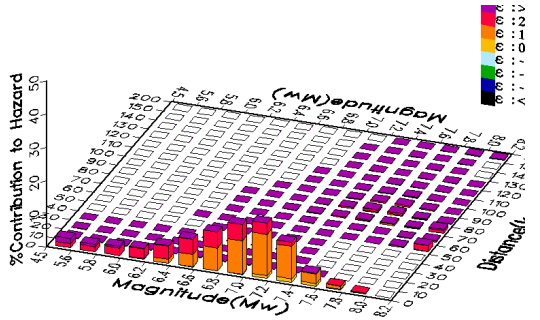




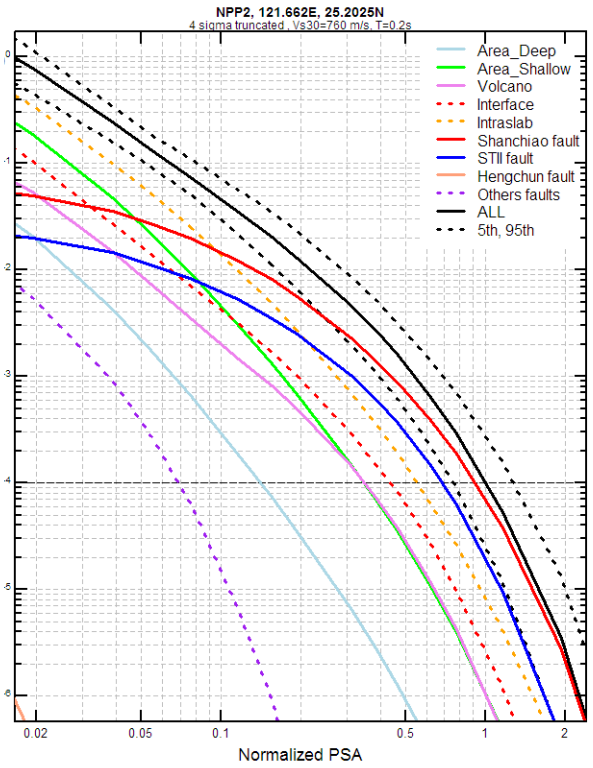
NPP2 - PGA - 5Hz – 0.5Hz

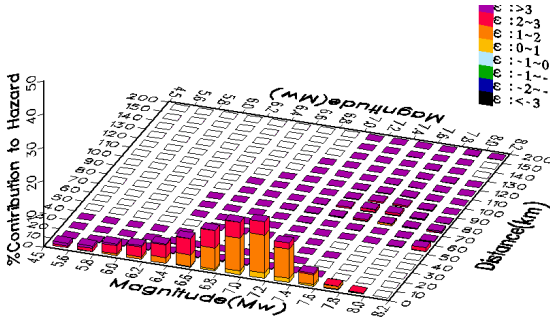
PGA



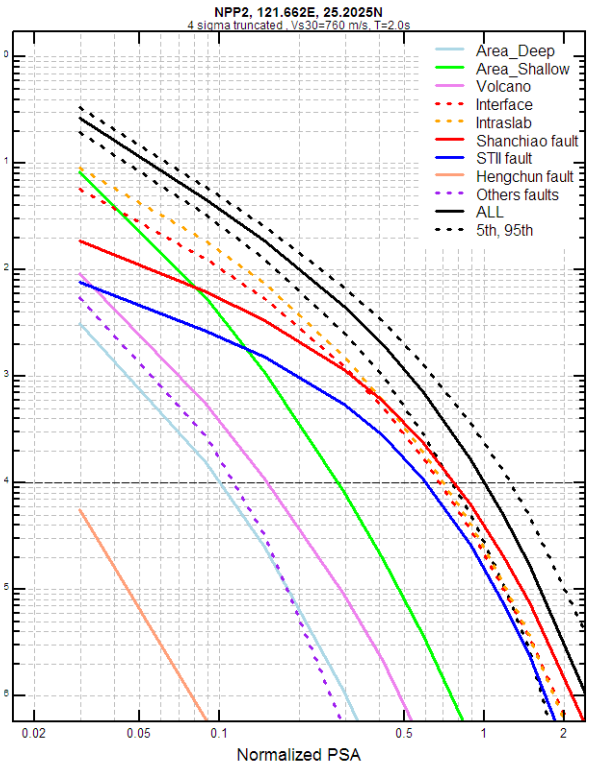


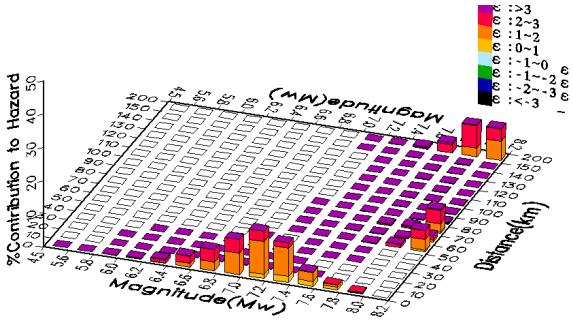
0.2s





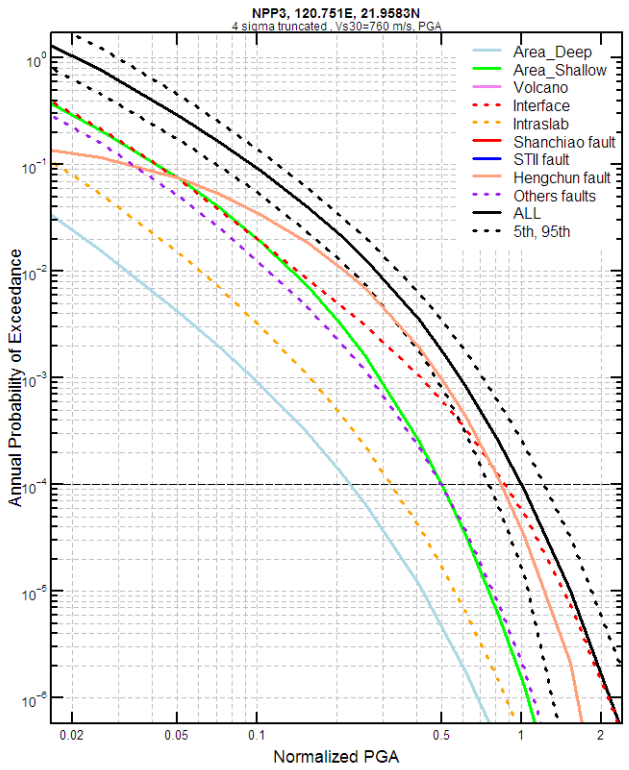
2.0s

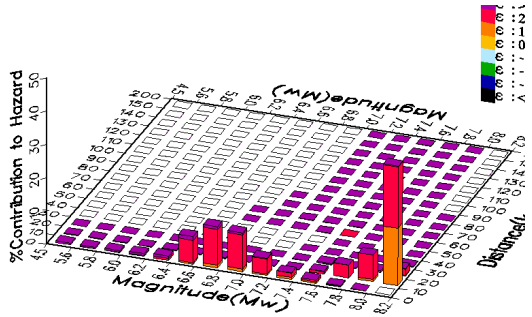




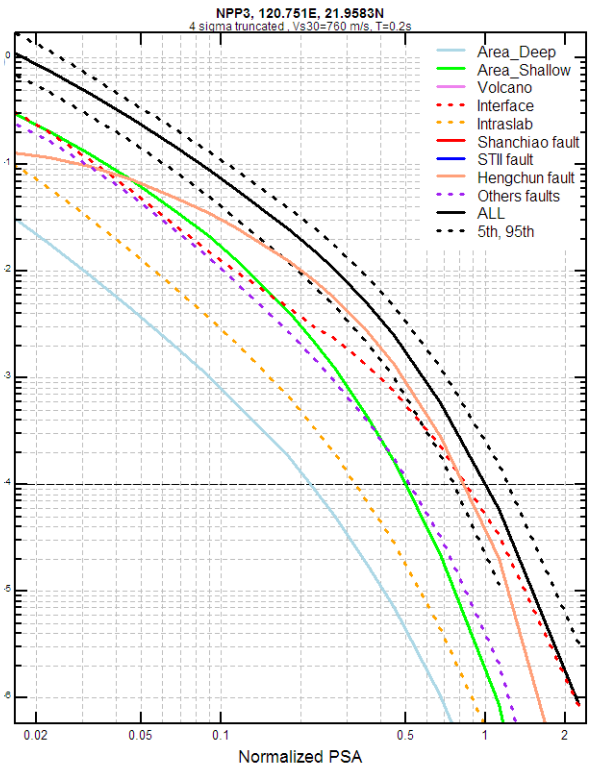
NPP3 - PGA - 5Hz – 0.5Hz

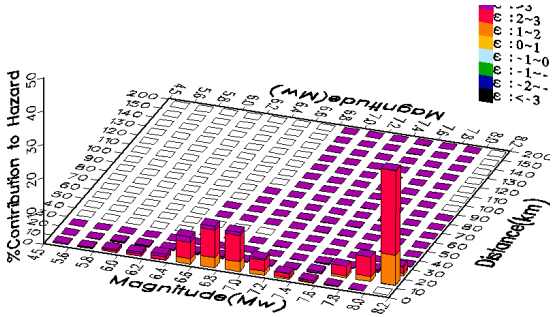
PGA



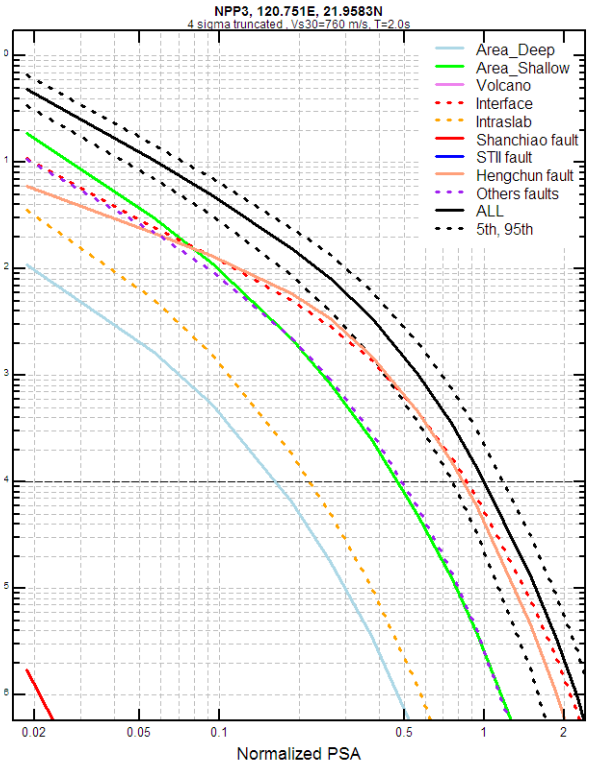


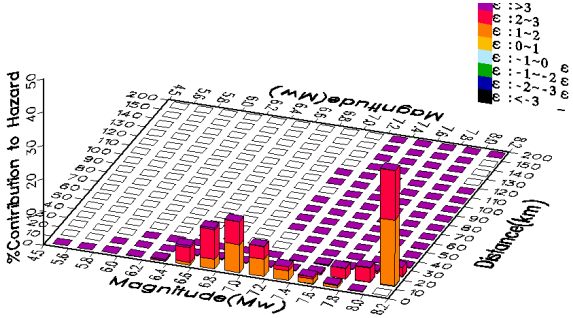
0.2s





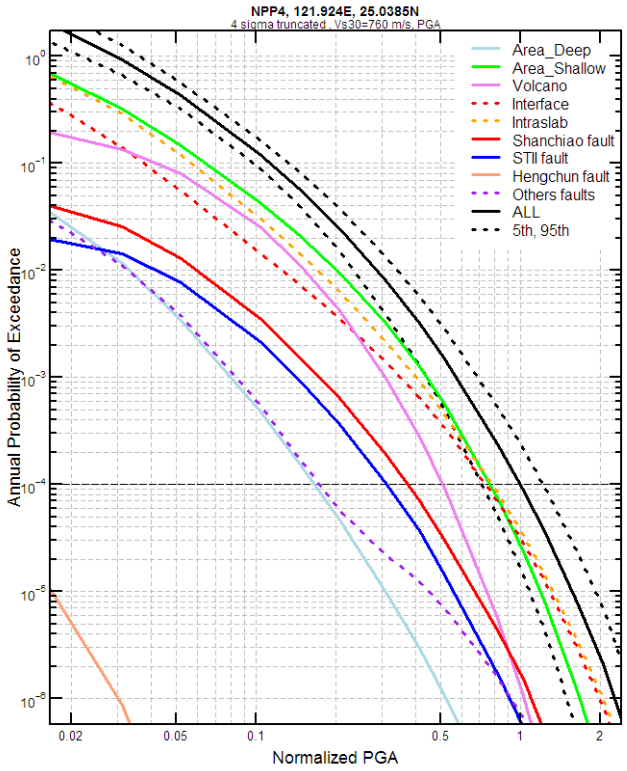
2.0s

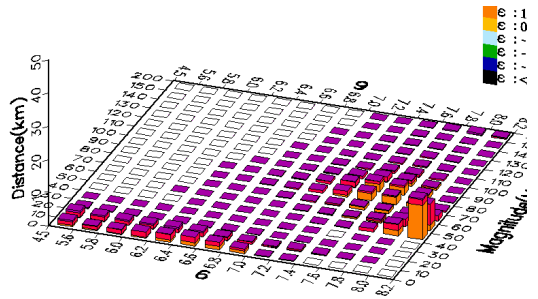




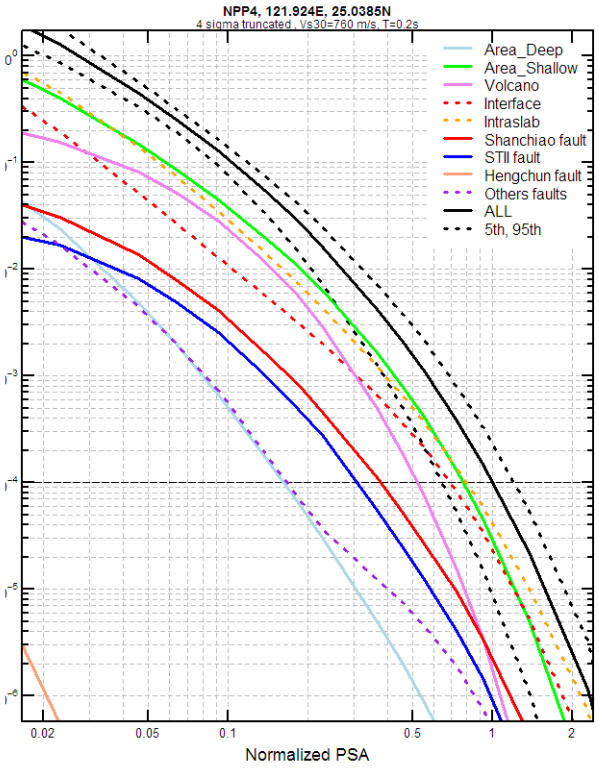
NPP4 - PGA - 5Hz – 0.5Hz

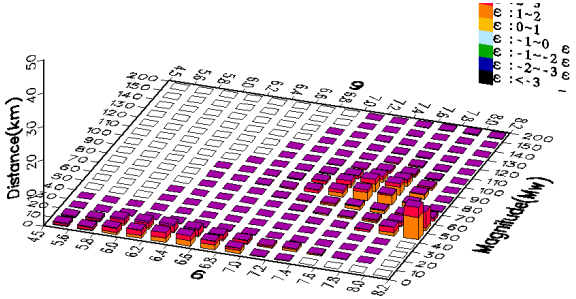
PGA



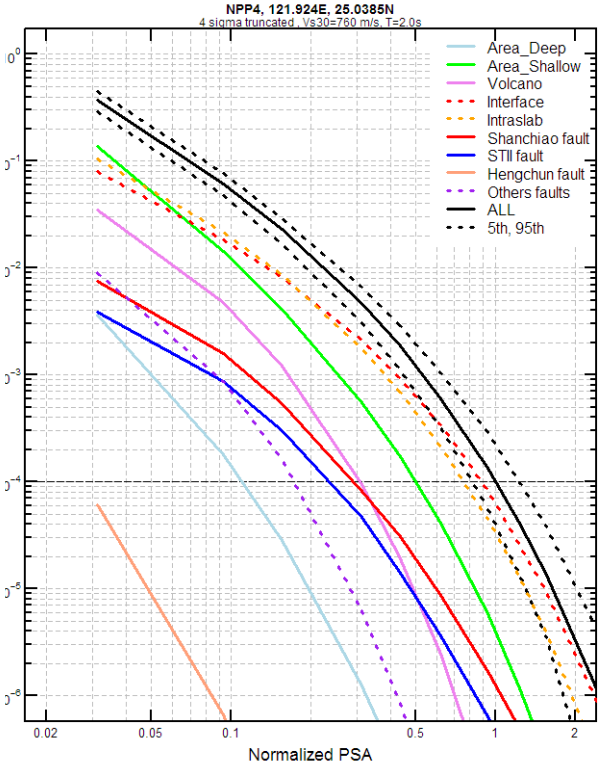


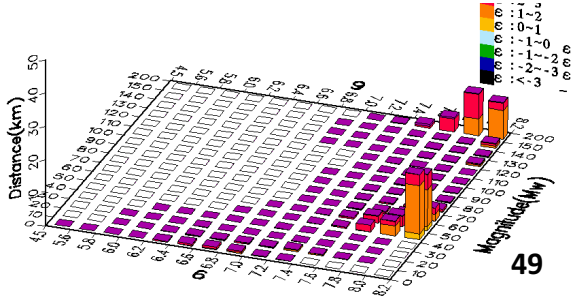
0.2s





2.0s



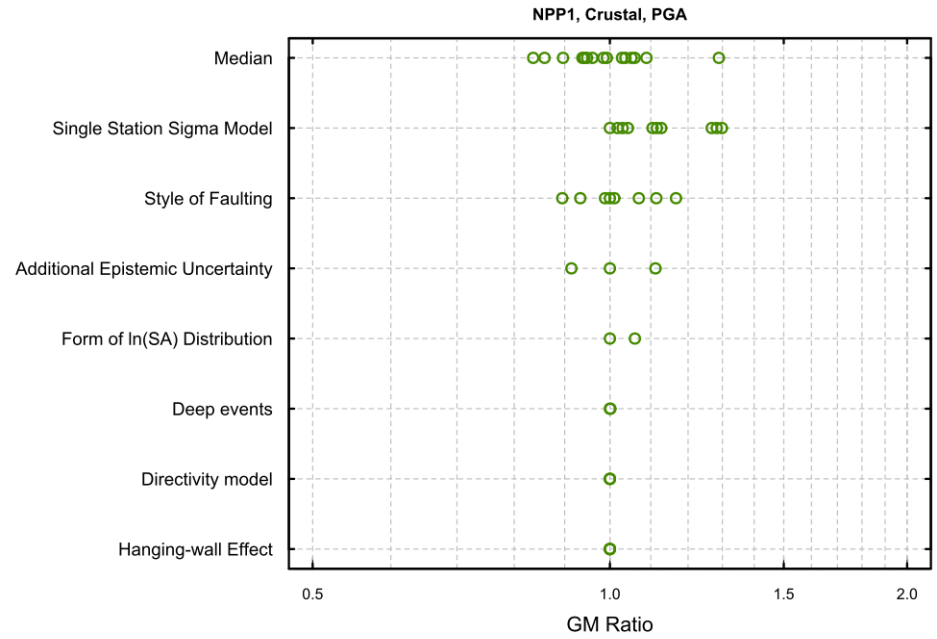


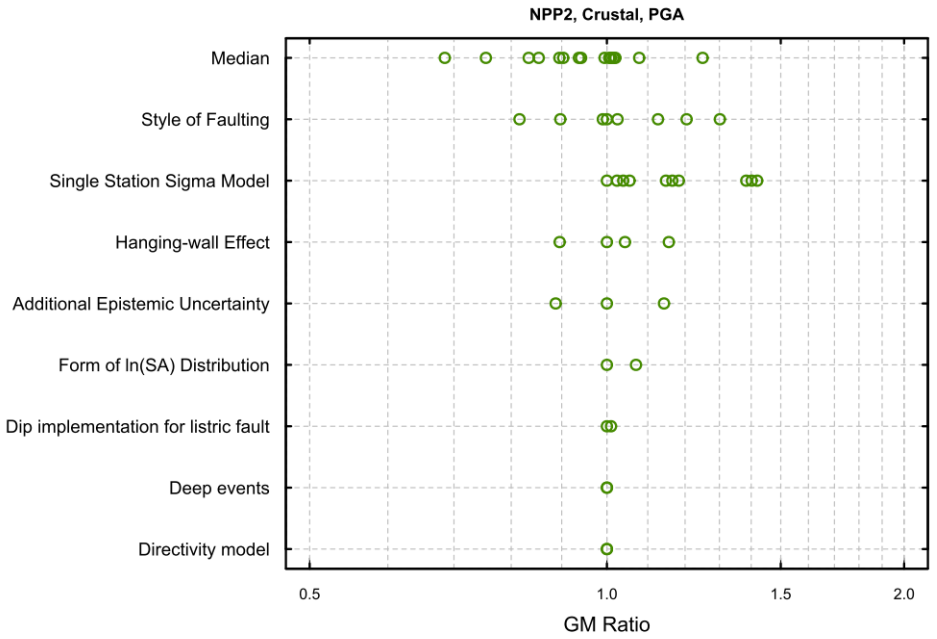
GMC Sensitivity cases – Crustal

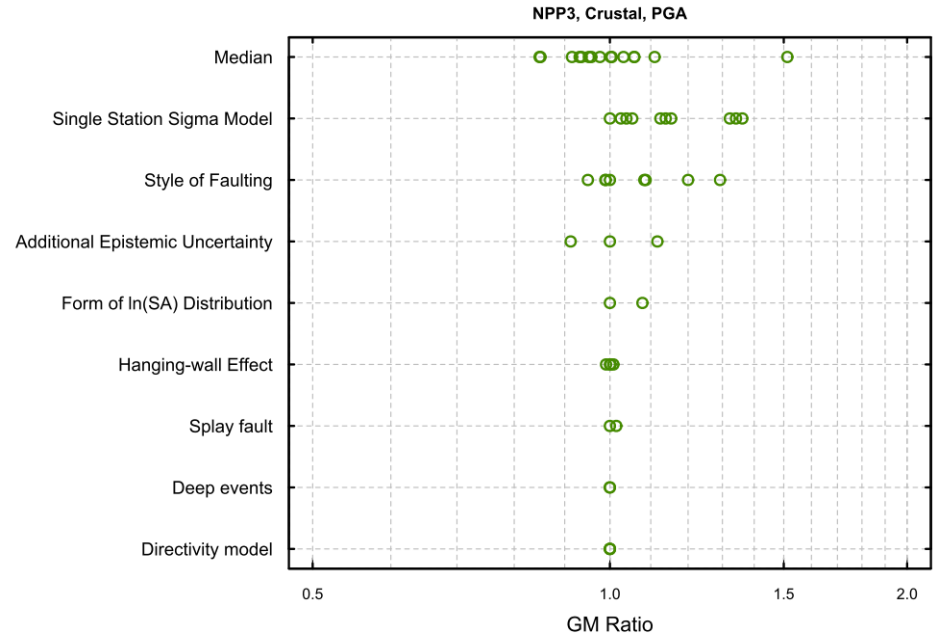
Node	Sensitivity Case	
1	GMPE for Median	Done before WM#3
2	Additional Epistemic Uncertainty for Median	
3	SigmaSS	
4	Form of Distribution of ln(SA)	
5	Splay fault	
6	Deep events	
7	Dip implementation for listric fault	
8	Directivity model	
9	Style of Faulting	
10	Hanging-wall Effect	

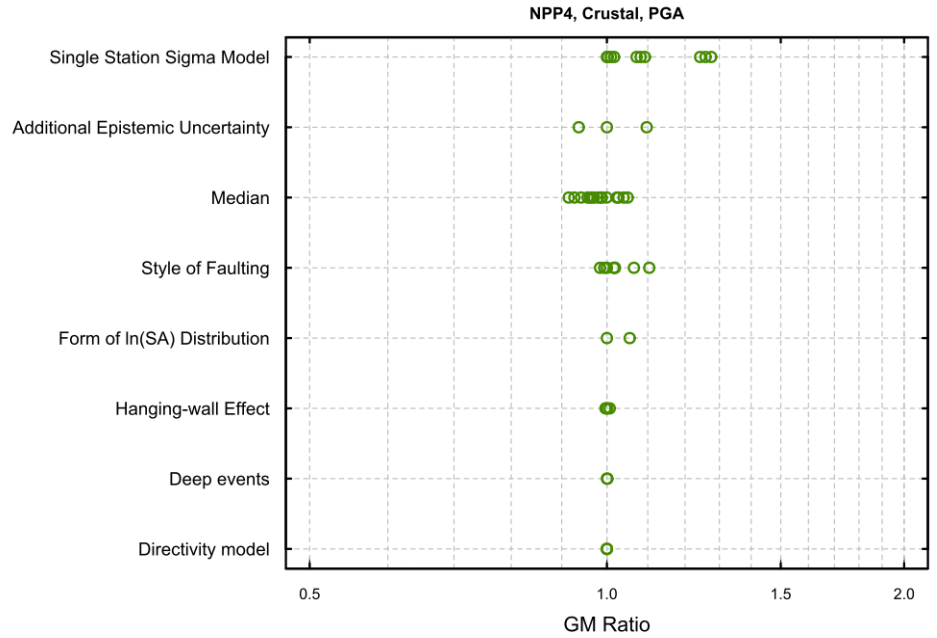
GMC Sensitivity cases – Subduction

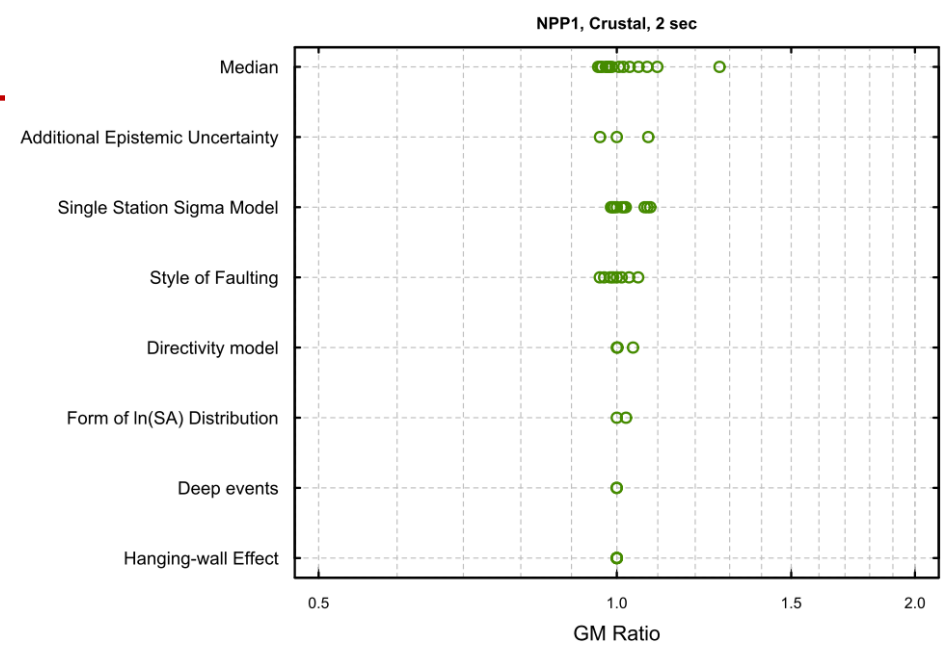
Node	Sensitivity Case	
1	GMPE for Median	Done before WM#3
2	Additional Epistemic Uncertainty for Median	
3	SigmaSS	
4	Form of Distribution of ln(SA)	
5	Depth scaling for intraslab	
6	Large Mag scaling for intraslab	
7	Edge Effect for interface	

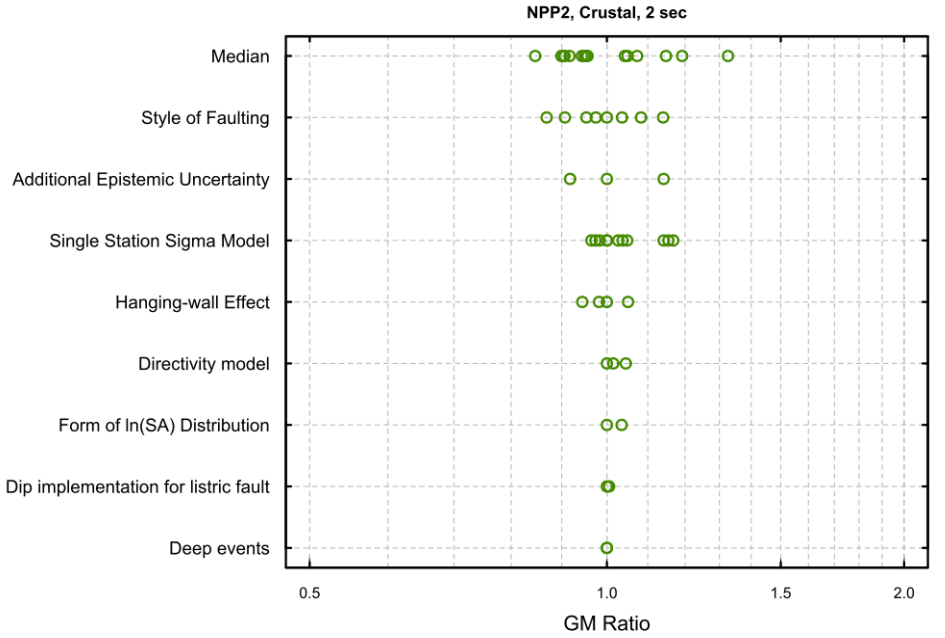

NPP1, Crustal, PGA
Median
Single Station Sigma Model
Style of Faulting
Additional Epistemic Uncertainty
Form of ln(SA) Distribution
Deep events
Directivity model
Hanging-wall Effect
0.5
1.0
1.5
2.0
GM Ratio

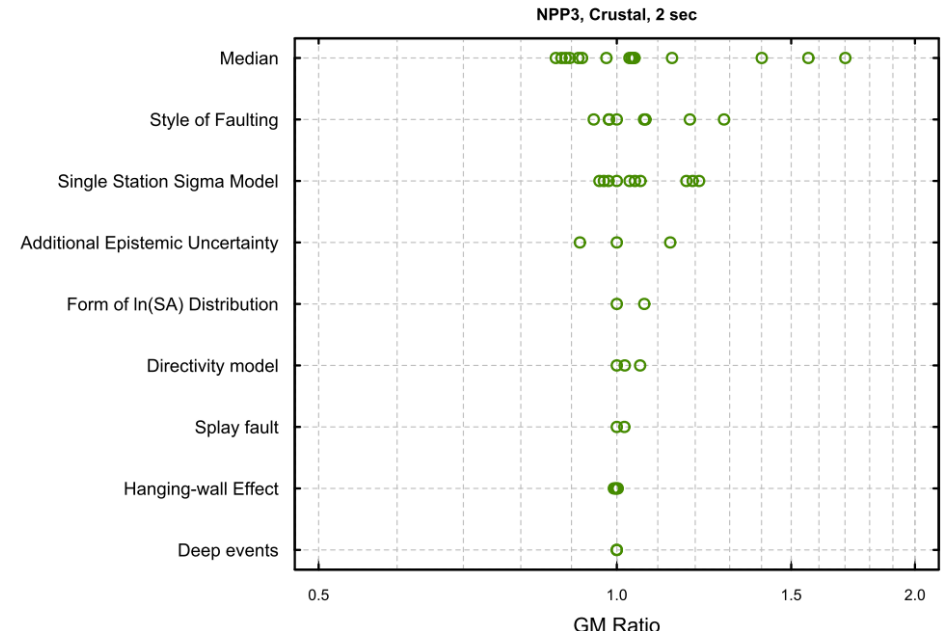

NPP2, Crustal, PGA
Median
Style of Faulting
Single Station Sigma Model
Hanging-wall Effect
Additional Epistemic Uncertainty
Form of ln(SA) Distribution
Dip implementation for listric fault
Deep events
Directivity model
0.5
1.0
1.5
2.0
GM Ratio

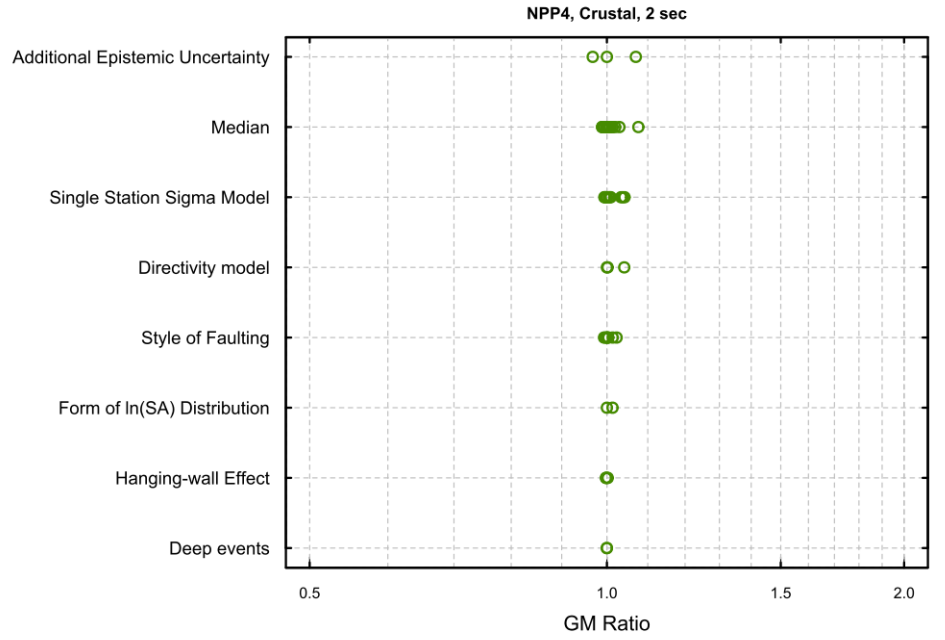

NPP3, Crustal, PGA
Median
Single Station Sigma Model
Style of Faulting
Additional Epistemic Uncertainty
Form of ln(SA) Distribution
Hanging-wall Effect
Splay fault
Deep events
Directivity model
0.5
1.0
1.5
2.0
GM Ratio

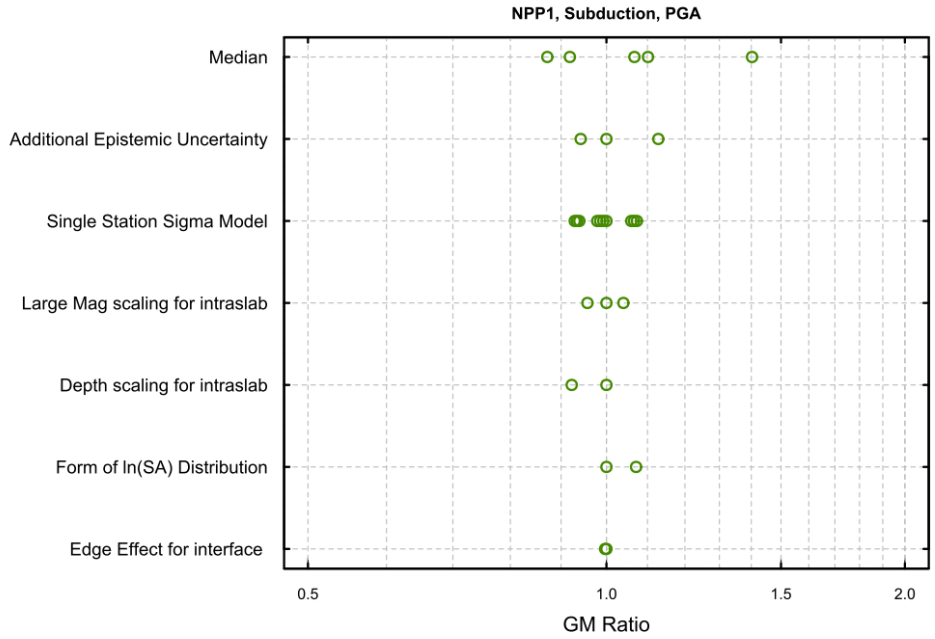

NPP4, Crustal, PGA
Single Station Sigma Model
Additional Epistemic Uncertainty
Median
Style of Faulting
Form of ln(SA) Distribution
Hanging-wall Effect
Deep events
Directivity model
0.5
1.0
1.5
2.0
GM Ratio

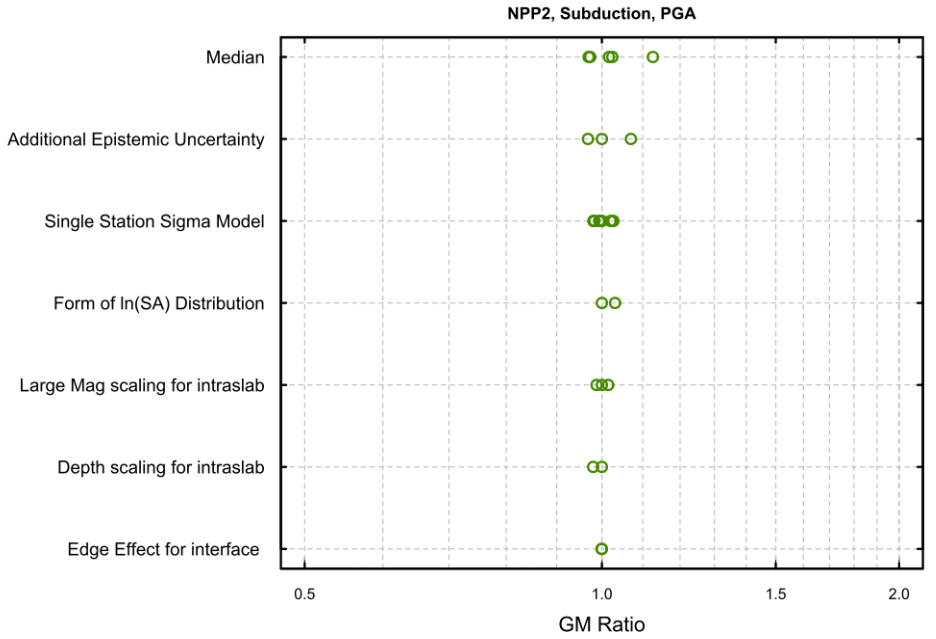

NPP1, Crustal, 2 sec
Median
Additional Epistemic Uncertainty
Single Station Sigma Model
Style of Faulting
Directivity model
Form of ln(SA) Distribution
Deep events
Hanging-wall Effect
0.5
1.0
1.5
2.0
GM Ratio

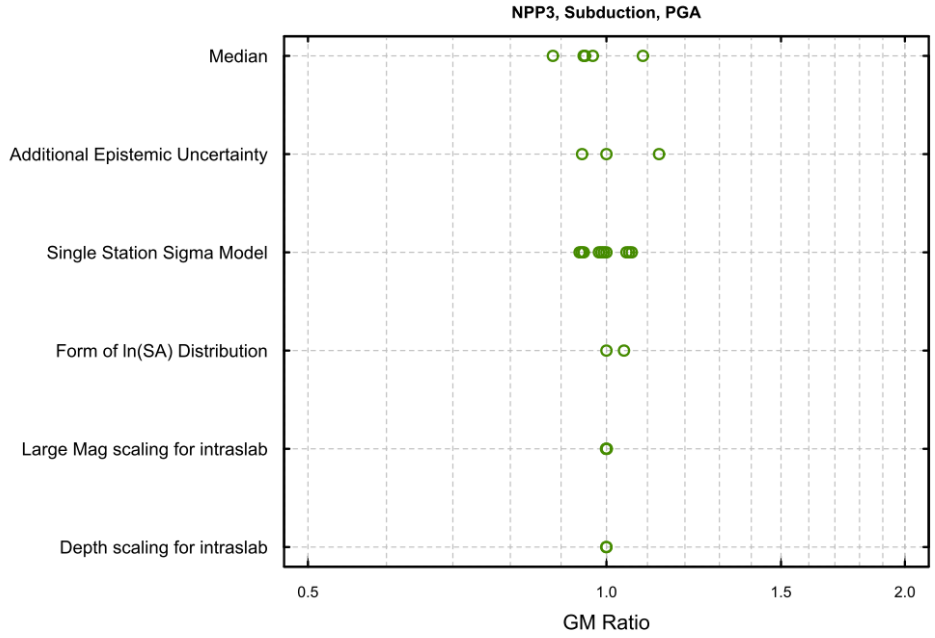

NPP2, Crustal, 2 sec
Median
Style of Faulting
Additional Epistemic Uncertainty
Single Station Sigma Model
Hanging-wall Effect
Directivity model
Form of ln(SA) Distribution
Dip implementation for listric fault
Deep events
0.5
1.0
1.5
2.0
GM Ratio

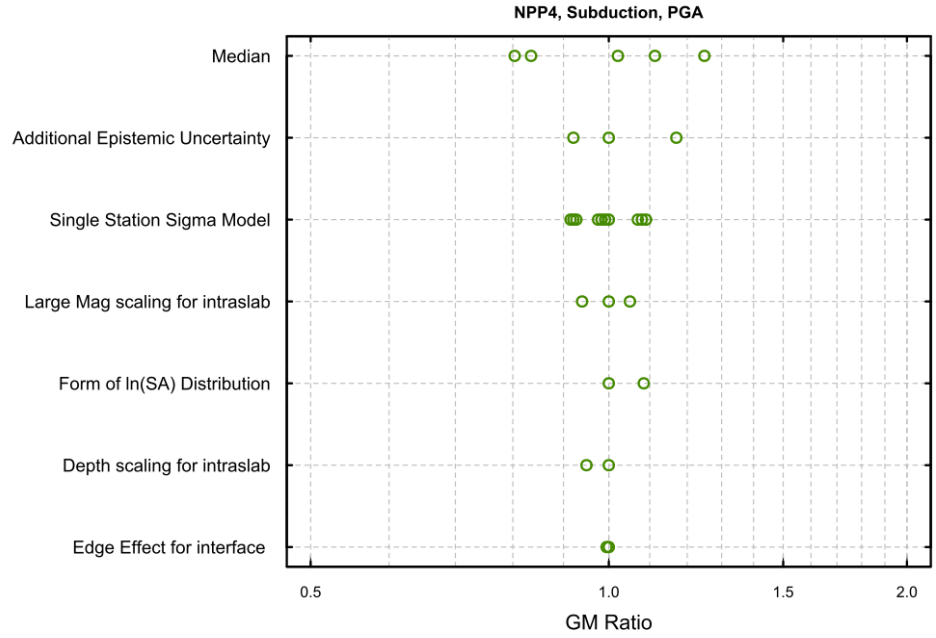

NPP3, Crustal, 2 sec
Median
Style of Faulting
Single Station Sigma Model
Additional Epistemic Uncertainty
Form of ln(SA) Distribution
Directivity model
Splay fault
Hanging-wall Effect
Deep events
0.5
1.0
1.5
2.0
GM Ratio

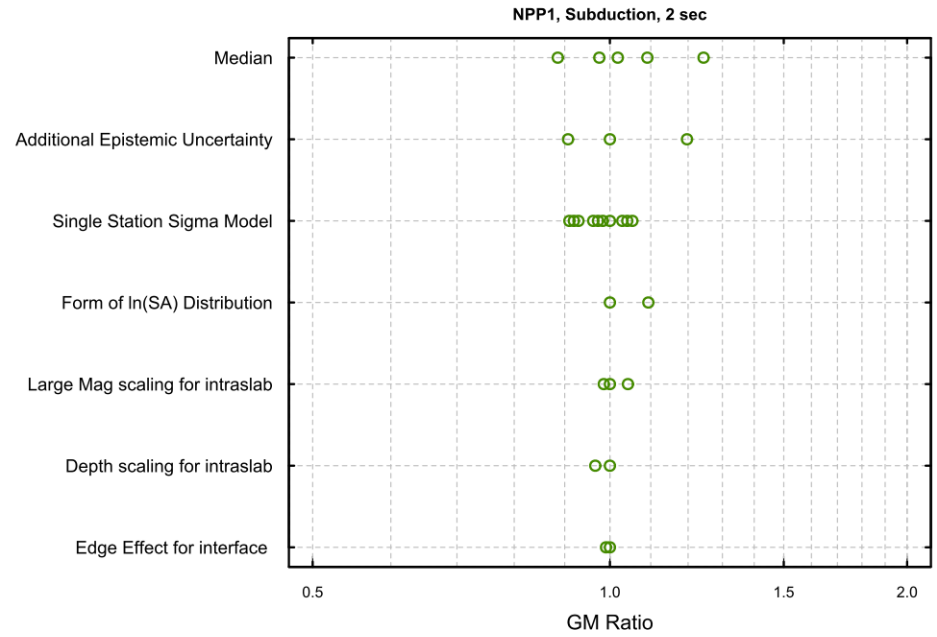

NPP4, Crustal, 2 sec
Additional Epistemic Uncertainty
Median
Single Station Sigma Model
Directivity model
Style of Faulting
Form of ln(SA) Distribution
Hanging-wall Effect
Deep events
0.5
1.0
1.5
2.0
GM Ratio

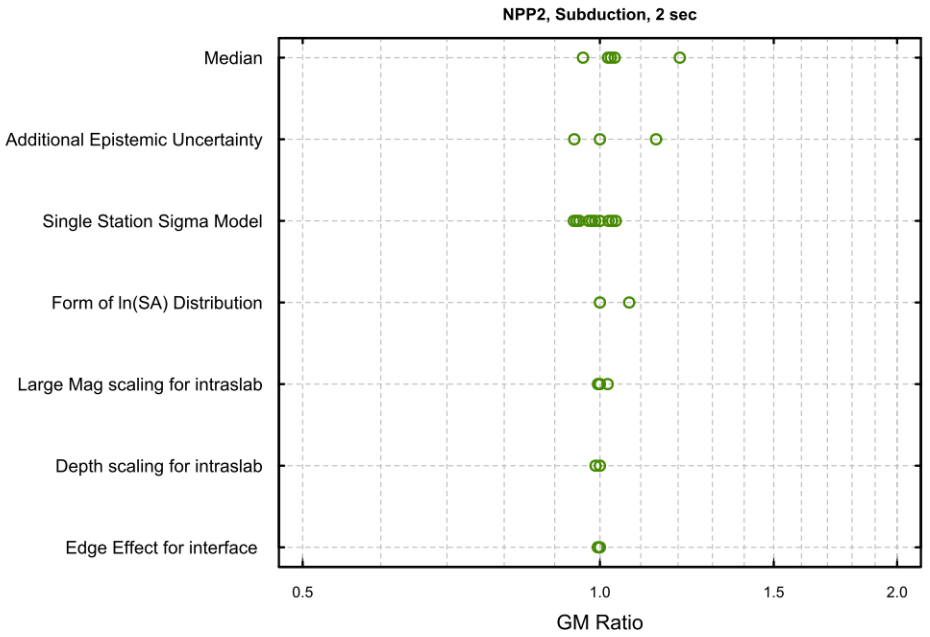

NPP1, Subduction, PGA
Median
Additional Epistemic Uncertainty
Single Station Sigma Model
Large Mag scaling for intraslab
Depth scaling for intraslab
Form of ln(SA) Distribution
Edge Effect for interface
0.5
1.0
1.5
2.0
GM Ratio

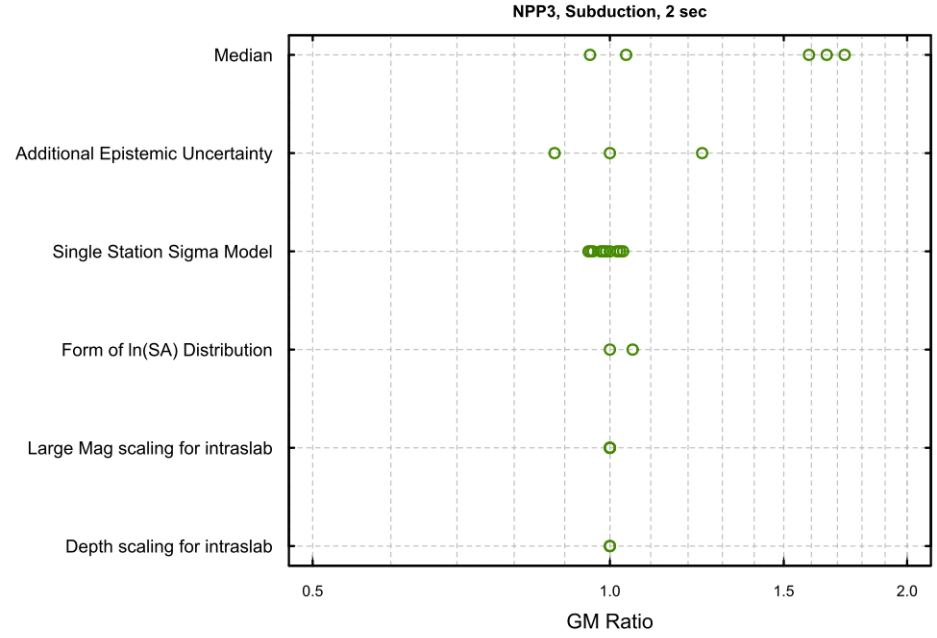

NPP2, Subduction, PGA
Median
Additional Epistemic Uncertainty
Single Station Sigma Model
Form of ln(SA) Distribution
Large Mag scaling for intraslab
Depth scaling for intraslab
Edge Effect for interface
0.5
1.0
1.5
2.0
GM Ratio

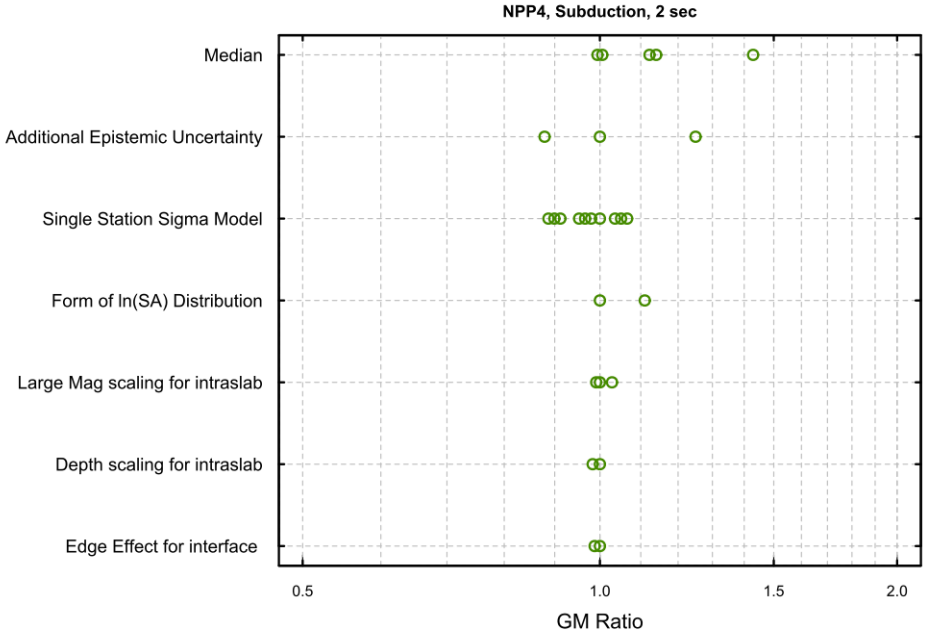

NPP3, Subduction, PGA
Median
Additional Epistemic Uncertainty
Single Station Sigma Model
Form of ln(SA) Distribution
Large Mag scaling for intraslab
Depth scaling for intraslab
0.5
1.0
1.5
2.0
GM Ratio


NPP4, Subduction, PGA
Median
Additional Epistemic Uncertainty
Single Station Sigma Model
Large Mag scaling for intraslab
Form of ln(SA) Distribution
Depth scaling for intraslab
Edge Effect for interface
0.5
1.0
1.5
2.0
GM Ratio


NPP1, Subduction, 2 sec
Median
Additional Epistemic Uncertainty
Single Station Sigma Model
Form of ln(SA) Distribution
Large Mag scaling for intraslab
Depth scaling for intraslab
Edge Effect for interface
0.5
1.0
1.5
2.0
GM Ratio


NPP2, Subduction, 2 sec
Median
Additional Epistemic Uncertainty
Single Station Sigma Model
Form of ln(SA) Distribution
Large Mag scaling for intraslab
Depth scaling for intraslab
Edge Effect for interface
0.5
1.0
1.5
2.0
GM Ratio


NPP3, Subduction, 2 sec
Median
Additional Epistemic Uncertainty
Single Station Sigma Model
Form of ln(SA) Distribution
Large Mag scaling for intraslab
Depth scaling for intraslab
0.5
1.0
1.5
2.0
GM Ratio


NPP4, Subduction, 2 sec
Median
Additional Epistemic Uncertainty
Single Station Sigma Model
Form of ln(SA) Distribution
Large Mag scaling for intraslab
Depth scaling for intraslab
Edge Effect for interface
0.5
1.0
1.5
2.0
GM Ratio