Set 3 Tests

Summary

3.1 Bending fault

3.2 Logic Tree, Fractiles

3.3 Intraslab Zone

3.4 Virtual Faults / Point Source Correction for Areal Sources

General Instructions (same as previous sets)

- Please provide mean hazard results (probability of exceedance) for peak horizontal acceleration (PGA) defined at 0.001, 0.01, 0.05, 0.1, 0.15, 0.2, 0.25, 0.3, 0.35, 0.4, 0.45, 0.5, 0.55, 0.6, 0.7, 0.8, 0.9, and 1.0 g.
- Assume a Poisson model when converting rates to annual probabilities of exceedance
- Use 16.05 (not 16.1) in the equation $\log M_o = 16.05 + 1.5\mathbf{M}$
- Use 3×10^{11} dyne/cm^2
- Use a magnitude integration step size small enough to define the specified magnitude density function. The bin size for magnitude integration should be defined such that the M_{min} is at the lower edge of a bin, not in the center (i.e., If your magnitude step size is 0.01, one magnitude bin should be from **M** 5.0 to 5.01)
- When integrating over the magnitude density function (balancing the moment), integrate from zero (not M_{min})
- Sigma = 0 for the ground motion model implies that the sigma in the relationship is artificially set to zero, not that the sigma is truncated
- Rupture dimension relationships:
  - $\log(A) = \mathbf{M} - 4$ $\sigma_A = 0$
  - $\log(W) = (0.5*\mathbf{M}) - 2.15$ $\sigma_W = 0$
  - $\log(L) = (0.5*\mathbf{M}) - 1.85$ $\sigma_L = 0$
  - ($\sigma_A = \sigma_W = \sigma_L = 0$ for all tests in this set)
  - Aspect Ratio (L/W) = 2
- Maintain the aspect ratio defined until maximum width is reached, then increase length (conservation of area at the expense of aspect ratio)
- Rupture plane location is uniformly distributed along strike and down dip. Do not allow rupture off the ends of fault. This results in uniform slip with tapered edges. Downdip and along-strike integration step size should be small enough to produce uniform rupture location.
- Use a hypocenter depth location in the geometric center of the rupture plane.
- You should be using as small a step size as feasible/necessary to produce stable results (for both magnitude density function and rupture distribution). This may be much smaller than you normally use on projects.

Test 3.1 – Bending fault

a. Dipping east

Description: Calculate the hazard for Sites 1 and 2 due to the bending fault.

Source: Fault 3.1a, L = 60 km, reverse, slip rate = 2 mm/yr
Fault plane depths = 0-12 km, dip 60° east

b. Dipping west

Description: Calculate the hazard for Sites 3 and 4 due to the bending fault.

Source: Fault 3.1b, L = 60 km, reverse, slip rate = 2 mm/yr
Fault plane depths = 0-12 km, dip 60° west

(applies to both)

Magnitude Density Function: delta function at **M** 6.75

Ground motion model: Chiou and Youngs 2014, σ untruncated

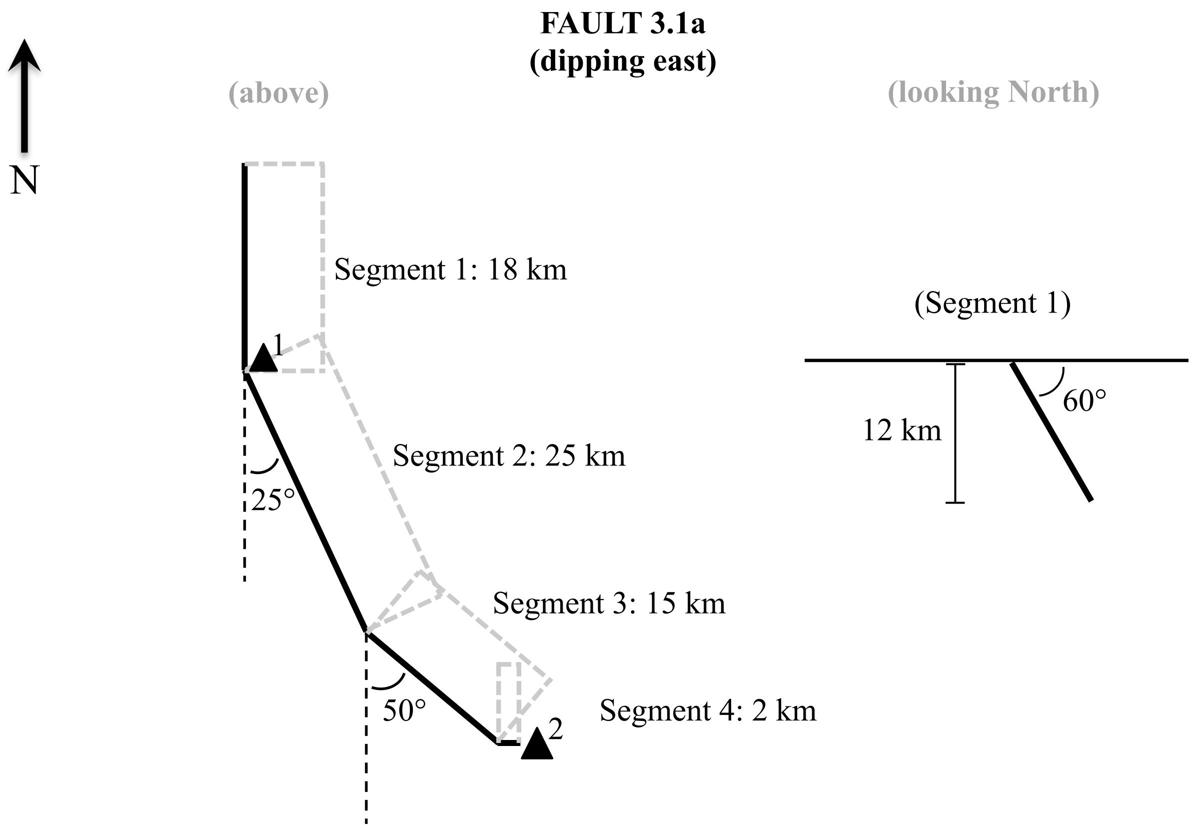
Damping ratio = 5%
V_{S30} = 760 m/s
V_{S30} is measured
$Z_{1.0}$ = 0.048 km
$Z_{2.5}$ = 0.607 km
Region = California

Also Report: the fault area, the top and bottom edges of the fault plane, a one sentence explanation of how your code calculates R_x for a bending fault

Recommended rupture location step size: 0.1 km

Note that in Figure 3.1, the surface projection of the fault (dashed grey line) is only meant to make it clear which direction the fault is dipping, it is not intended to indicate the correct way to model the fault geometry

Figure 3.1 – Bending fault



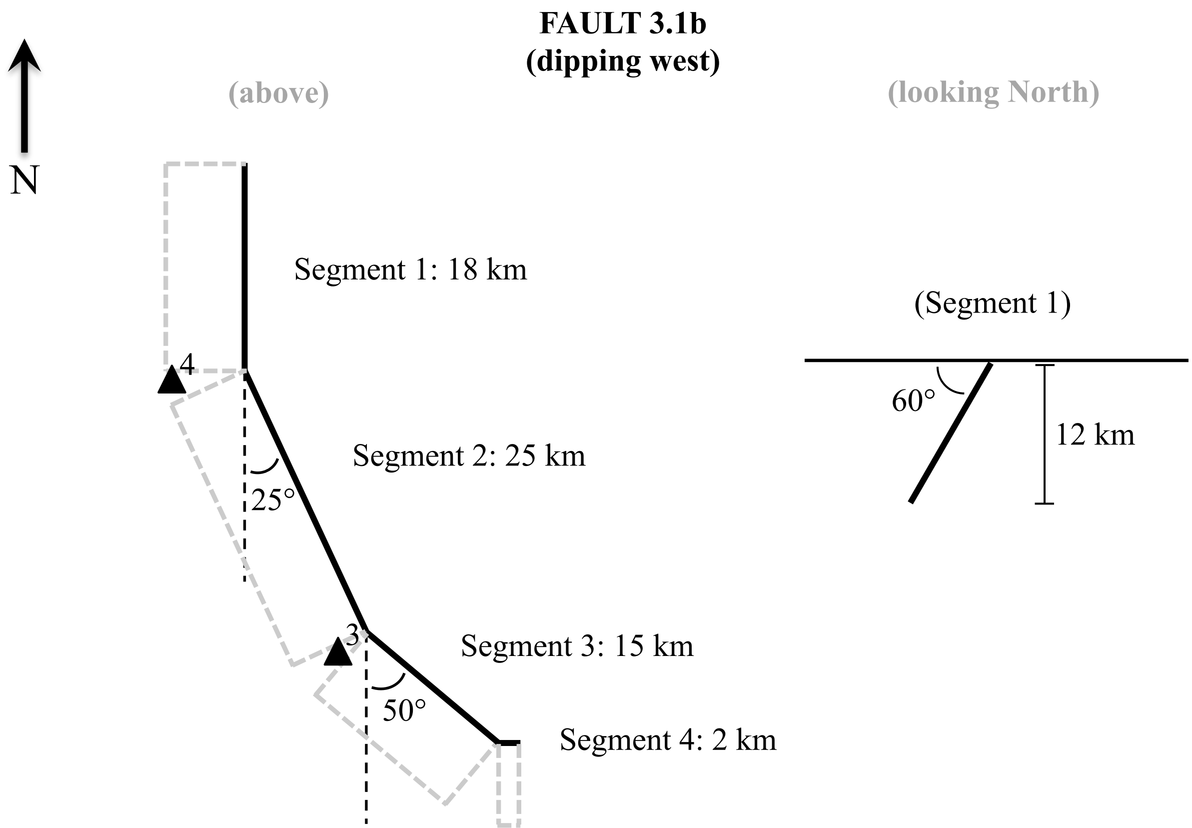
Fault coordinates

Latitude	Longitude	Comment
0.00000	-65.00000	North end of Segment 1
-0.16188	-65.00000	South end of Segment 1/North end of Segment 2
-0.36564	-64.90498	South end of Segment 2/North end of Segment 3
-0.45236	-64.80164	South end of Segment 3/West end of Segment 4
-0.45236	-64.78365	East end of Segment 4

Site coordinates

Site	Latitude	Longitude	Comment
1	-0.15738	-64.98651	1.5 km east, 0.5 km north of Seg 1/2 intersect
2	-0.45686	-64.77466	1 km east, 0.5 km south of Seg 4 East end

Figure 3.1 – Bending fault



Fault coordinates

Latitude	Longitude	Comment
0.00000	-65.00000	North end of Segment 1
-0.16188	-65.00000	South end of Segment 1/North end of Segment 2
-0.36564	-64.90498	South end of Segment 2/North end of Segment 3
-0.45236	-64.80164	South end of Segment 3/West end of Segment 4
-0.45236	-64.78365	East end of Segment 4

Site coordinates

Site	Latitude	Longitude	Comment
3	-0.38363	-64.92747	2.5 km west, 2 km south of Seg 3/4 intersect
4	-0.17088	-65.05396	6 km west, 1 km south of Seg 1/2 intersect

Test 3.2 – Logic Tree, Fractiles

Description: Calculate the hazard for the site shown in Figure 3.2 due to Fault 3.2, using the specifications and logic tree below. Report mean hazard, 10^{th}, 50^{th} (median), and 90^{th} fractiles.

Source: Fault 3.2, L = 85 km, fault plane depths = 0-12 km, strike-slip, dip 90°, slip rate varies

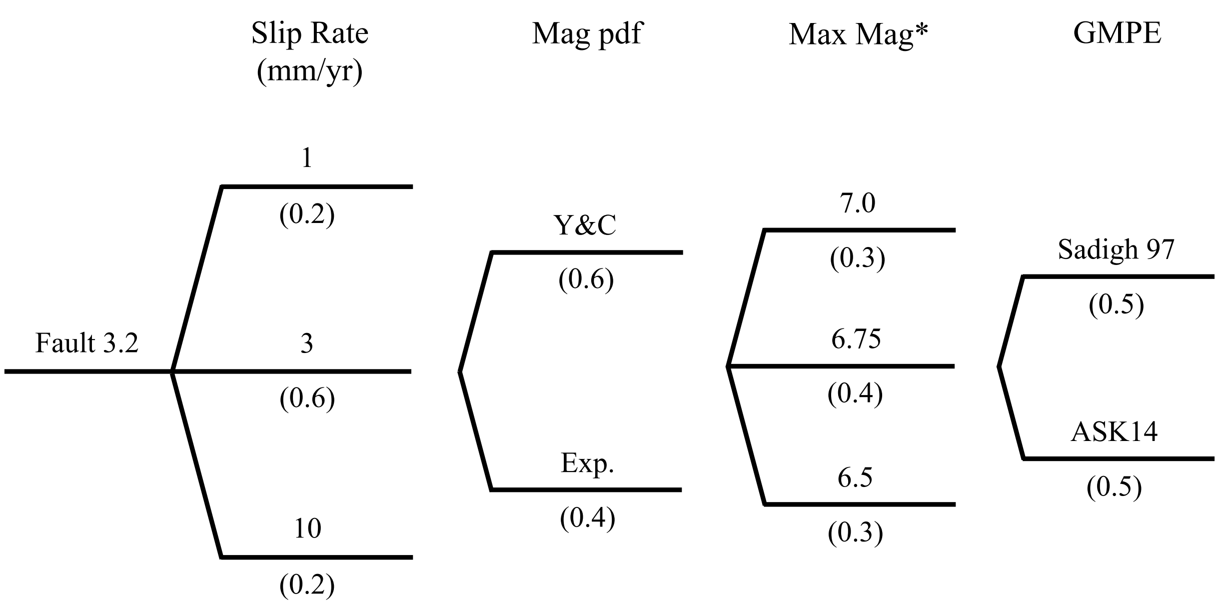
Magnitude Density Functions:

Truncated exponential: M_{min} = 5.0, M_{max} varies, b-value = 0.9
Youngs and Coppersmith: M_{min} = 5.0, M_{char} varies, M_{max} varies, b-value = 0.9

Ground motion models:

Sadigh 1997, Rock, σ untruncated

Abrahamson, Silva, and Kamai 2014, σ untruncated
Damping ratio = 5%
V_{S30} = 760 m/s
V_{S30} is measured
$Z_{1.0}$ = 0.048 km
$Z_{2.5}$ = 0.607 km
Region = California



*For the truncated exponential magnitude pdf, the max magnitude in the logic tree is the max value at the high end where the pdf is truncated. For the Youngs and Coppersmith magnitude pdf, this max magnitude is the mean characteristic magnitude in the center of the box car. So for max magnitude = 7.0 on the logic tree, the Youngs and Coppersmith pdf would have M_{char} = 7.0, M_{max} = 7.25.

Test 3.2 – Logic Tree, Fractiles

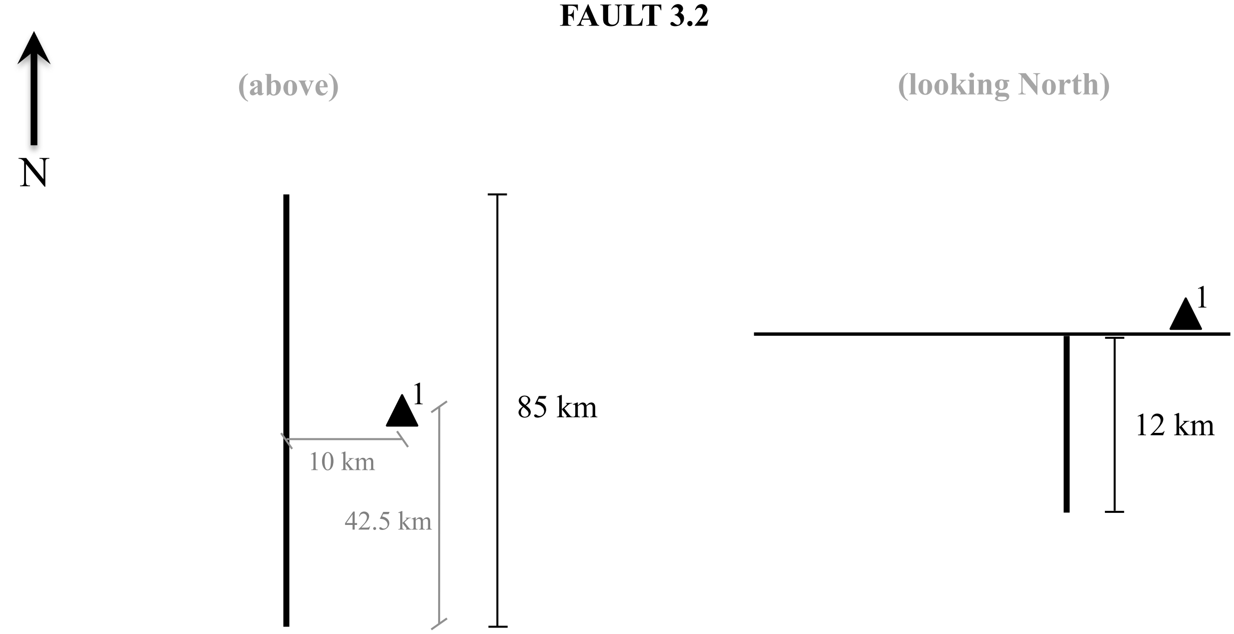
Also Report: how you interpolated to get the fractiles

You may want to start with your input files from Test 2.2a, Site 1, as the latitude/longitude coordinates are the same

There is no correlation between branches on the logic tree – just run every possible combination, which will result in 36 different combinations.

Figure 3.2 – Logic Tree, Fractiles

FAULT 3.2



Note: figures not to scale

Fault coordinates

Latitude	Longitude	Comment
0.38221	-65.00000	North end of fault
-0.38221	-65.00000	South end of fault

Site coordinates

Site	Latitude	Longitude	Comment
1	0.00000	-64.91005	10 km east of fault, at midpoint along strike

Test 3.3 – Intraslab Zone

Description: Calculate the hazard for the 2 sites shown in Figure 3.3 due to the intraslab zone.

Magnitude Density Function: truncated exponential, M_{min} = 5.0, M_{max}= 7.0 ~~8.0~~, b-value = 0.8

Source: Intraslab zone, slab thickness = 12.5 ~~10~~ km, N(M_{min}>5) = 0.013 eq/yr

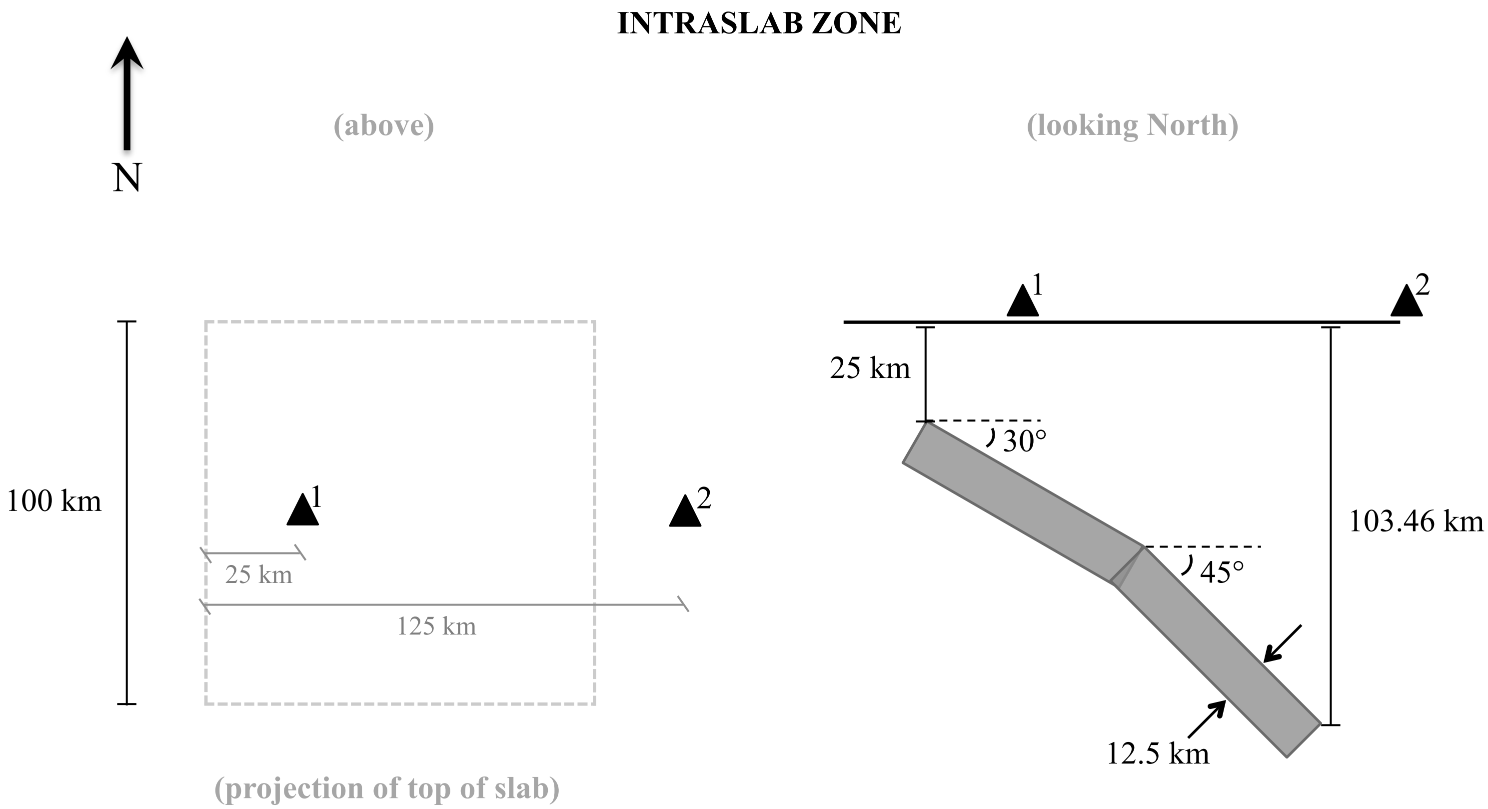
Ground motion model: Zhao et al 2006, Site Class I, Rock, σ untruncated

Also Report: a one sentence explanation of how your code models intraslab zones (which approach you used). Please also indicate whether this is how you have historically modeled intraslab zones, or if you are switching to a new approach going forward.

As discussed at the last meeting, assume that the R_{rup} predictor variable in Zhao et al 2006 was appropriately derived from rupture dimensions (even though previous data sets for subduction ground motion models likely only included hypocentral distance). The reason for this assumption is that the new NGA-Subduction ground motion models will include rupture distances which are appropriately derived from rupture dimensions, and we want the approach for modeling intraslab zones in the codes to make sense with the new NGA-Subduction ground motion models.

You can assume that the average dip of the ruptures, relative to the slab, is 35° ~~45°.~~ This is consistent with the NGA-Subduction data set, which includes a large range of dips, with an average of approximately 35° ~~45°~~ (relative to the slab dip). You can also use an aspect ratio of 2 if you utilize an approach that creates finite ruptures and requires a decision on the aspect ratio. The average aspect ratio from the NGA-Subduction data set is closer to 1.5, but let's use 2 since that's what's specified for all other tests in the project.

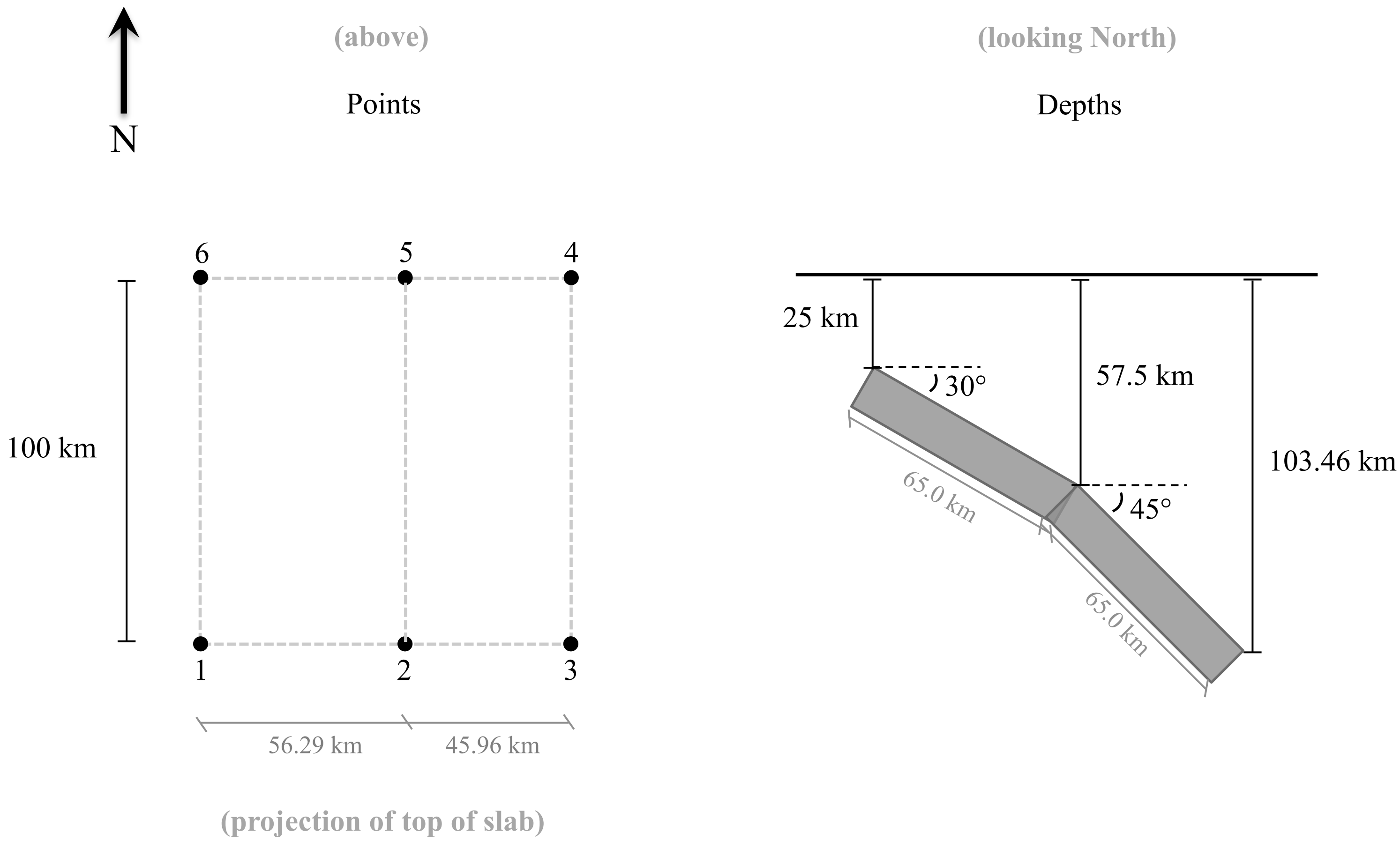
Figure 3.3 – Intraslab Zone



Site coordinates

Site	Latitude	Longitude	Comment
1	0.00000	-65.28146	25 km east of western edge of projection
2	0.00000	-64.38200	125 km east of western edge of projection

Figure 3.3 – Intraslab Zone



Slab coordinates (projection of top of slab)

Point	Latitude	Longitude	Comment
1	-0.44967	-65.50625	Southernmost point of western edge projection
2	-0.44967	-65.00000	Southernmost point where slope changes
3	-0.44967	-64.58666	Southernmost point of eastern edge projection
4	0.44967	-64.58666	Northernmost point of eastern edge projection
5	0.44967	-65.00000	Northernmost point where slope changes
6	0.44967	-65.50625	Northernmost point of western edge projection

Test 3.4 –Virtual Faults / Point Source Correction for Areal Sources

Description: Calculate the hazard for the 4 sites shown in Figure 3.4 due to the area zone. Use virtual faults or a point source correction to account for the rupture dimensions.

Magnitude Density Function: truncated exponential, M_{min} = 5.0, M_{max}= 6.5, b-value = 0.9

Source: Area source zone, depths 5-25 km, N(M_{min}>5) = 0.0395 eq/yr

Ground motion model: Chiou and Youngs 2014, σ untruncated

Damping ratio = 5%
V_{S30} = 760 m/s
V_{S30} is measured
$Z_{1.0}$ = 0.048 km
$Z_{2.5}$ = 0.607 km
Region = California

Fault styles: Strike slip = 60%, Normal = 20%, Reverse = 20%

Dip angles: Strike slip = 90°, Normal = 60°, Reverse = 30°

Strike = 0.0 (fix the strike in the north direction)

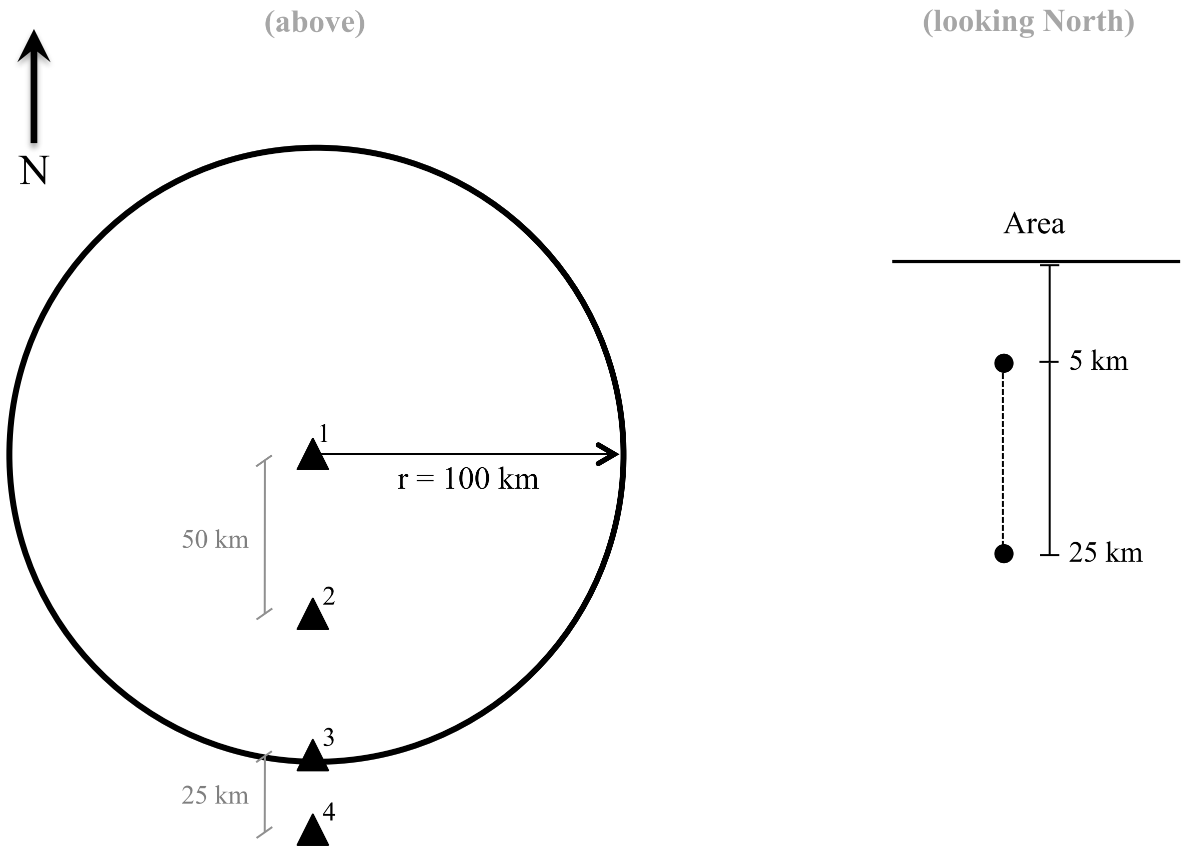
As discussed at the last meeting, it is ok to allow virtual faults to extend beyond the area source boundary.

You may want to start with your input files from Test 2.1, as the area source latitude/longitude coordinates are the same.

As far as spacing of the sources, we are trying to model a uniform/continuous distribution. Let's start with a 1 km grid spacing on the horizontal plane. Also use 1 km spacing with depth, inclusive of 5 km and 25 km. Use equal weights for all depths.

Please use an aspect ratio of 2 for the ruptures.

Figure 3.4 – Virtual Faults / Points Source Correction for Areal Sources



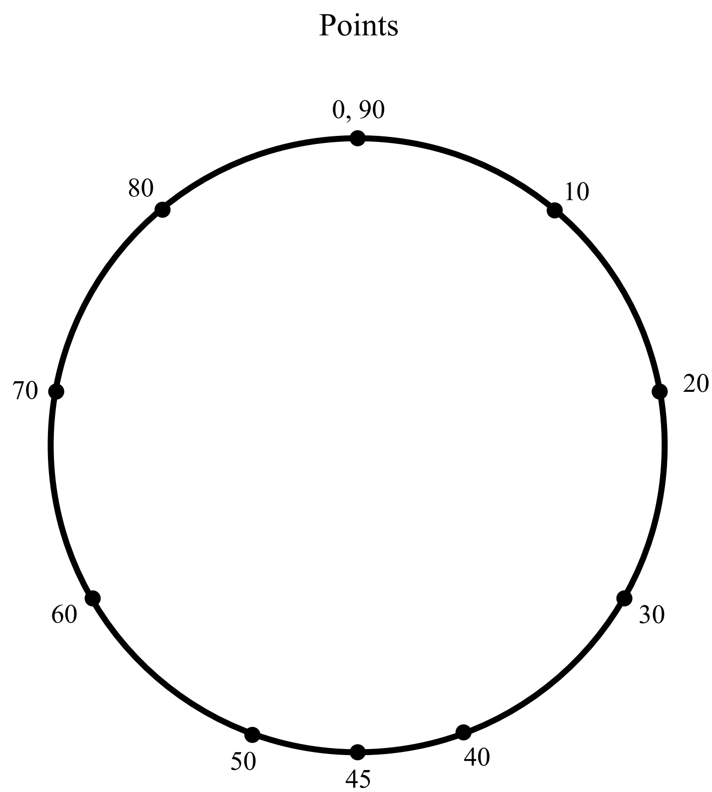
Note: figures not to scale

Site coordinates

Site	Latitude	Longitude	Comment
1	0.0000	-65.0000	In center of area source
2	-0.4497	-65.0000	50 km from center (radially)
3	-0.8993	-65.0000	On area boundary
4	-1.1242	-65.0000	25 km from boundary

Area source coordinates

Point	Latitude	Longitude
0	0.8993	-65.0000
1	0.8971	-64.9373
2	0.8906	-64.8748
3	0.8797	-64.8130
4	0.8645	-64.7521
5	0.8451	-64.6924
6	0.8216	-64.6342
7	0.7940	-64.5778
8	0.7627	-64.5234
9	0.7276	-64.4714
10	0.6899	-64.4219
11	0.6469	-64.3753
12	0.6017	-64.3316
13	0.5537	-64.2913
14	0.5029	-64.2544
15	0.4496	-64.2211
16	0.3942	-64.1917
17	0.3369	-64.1662
18	0.2779	-64.1447
19	0.2176	-64.1274
20	0.1562	-64.1143
21	0.0940	-64.1056
22	0.0314	-64.1012
23	-0.0314	-64.1012
24	-0.0940	-64.1056
25	-0.1562	-64.1143
26	-0.2176	-64.1274
27	-0.2779	-64.1447



Area source coordinates

Point	Latitude	Longitude
28	-0.3369	-64.1662
29	-0.3942	-64.1917
30	-0.4496	-64.2211
31	-0.5029	-64.2544
32	-0.5537	-64.2913
33	-0.6017	-64.3316
34	-0.6469	-64.3753
35	-0.6889	-64.4219
36	-0.7276	-64.4714
37	-0.7627	-64.5234
38	-0.7940	-64.5778
39	-0.8216	-64.6342
40	-0.8451	-64.6924
41	-0.8645	-64.7521
42	-0.8797	-64.8130
43	-0.8906	-64.8748
44	-0.8971	-64.9373
45	-0.8993	-65.0000
46	-0.8971	-65.0627
47	-0.8906	-65.1252
48	-0.8797	-65.1870
49	-0.8645	-65.2479
50	-0.8451	-65.3076
51	-0.8216	-65.3658
52	-0.7940	-65.4222
53	-0.7627	-65.4766
54	-0.7276	-65.5286

Point	Latitude	Longitude
55	-0.6889	-65.5781
56	-0.6469	-65.6247
57	-0.6017	-65.6684
58	-0.5537	-65.7087
59	-0.5029	-65.7456
60	-0.4496	-65.7789
61	-0.3942	-65.8083
62	-0.3369	-65.8338
63	-0.2779	-65.8553
64	-0.2176	-65.8726
65	-0.1562	-65.8857
66	-0.0940	-65.8944
67	-0.0314	-65.8988
68	0.0314	-65.8988
69	0.0940	-65.8944
70	0.1562	-65.8857
71	0.2176	-65.8726
72	0.2779	-65.8553
73	0.3369	-65.8338
74	0.3942	-65.8083
75	0.4496	-65.7789
76	0.5029	-65.7456
77	0.5537	-65.7087
78	0.6017	-65.6684
79	0.6469	-65.6247
80	0.6889	-65.5781
81	0.7276	-65.5286

Area source coordinates

Point	Latitude	Longitude
82	0.7627	-65.4766
83	0.7940	-65.4222
84	0.8216	-65.3658
85	0.8451	-65.3076
86	0.8645	-65.2479
87	0.8797	-65.1870
88	0.8906	-65.1252
89	0.8971	-65.0627
90	0.8993	-65.0000

(Point 90 is a duplicate of point 0 and closes the circle)