Implementation of Rupture Directivity in the 2007 Revision of the National Hazard Maps

September 25, 2006

Jennie Watson-Lamprey

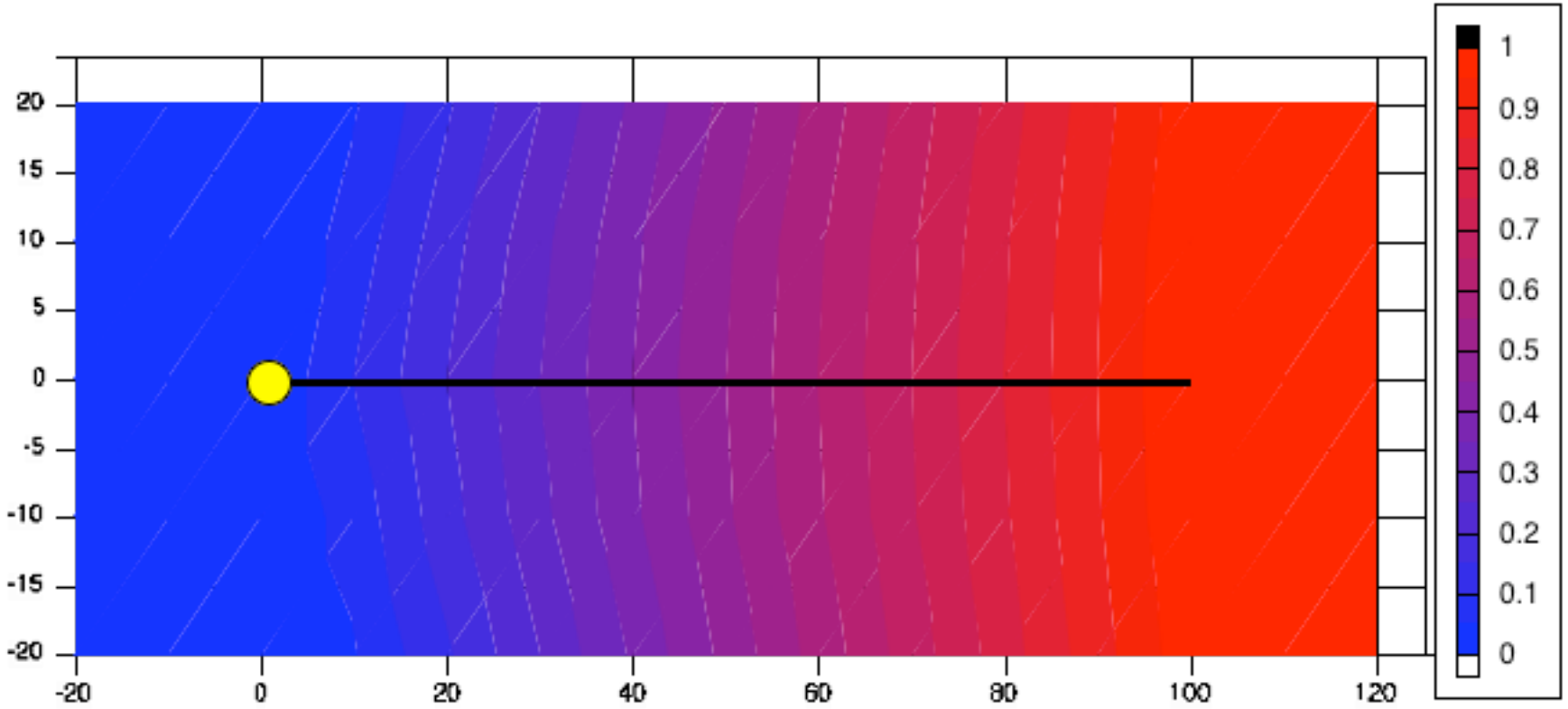
Issues of Implementation

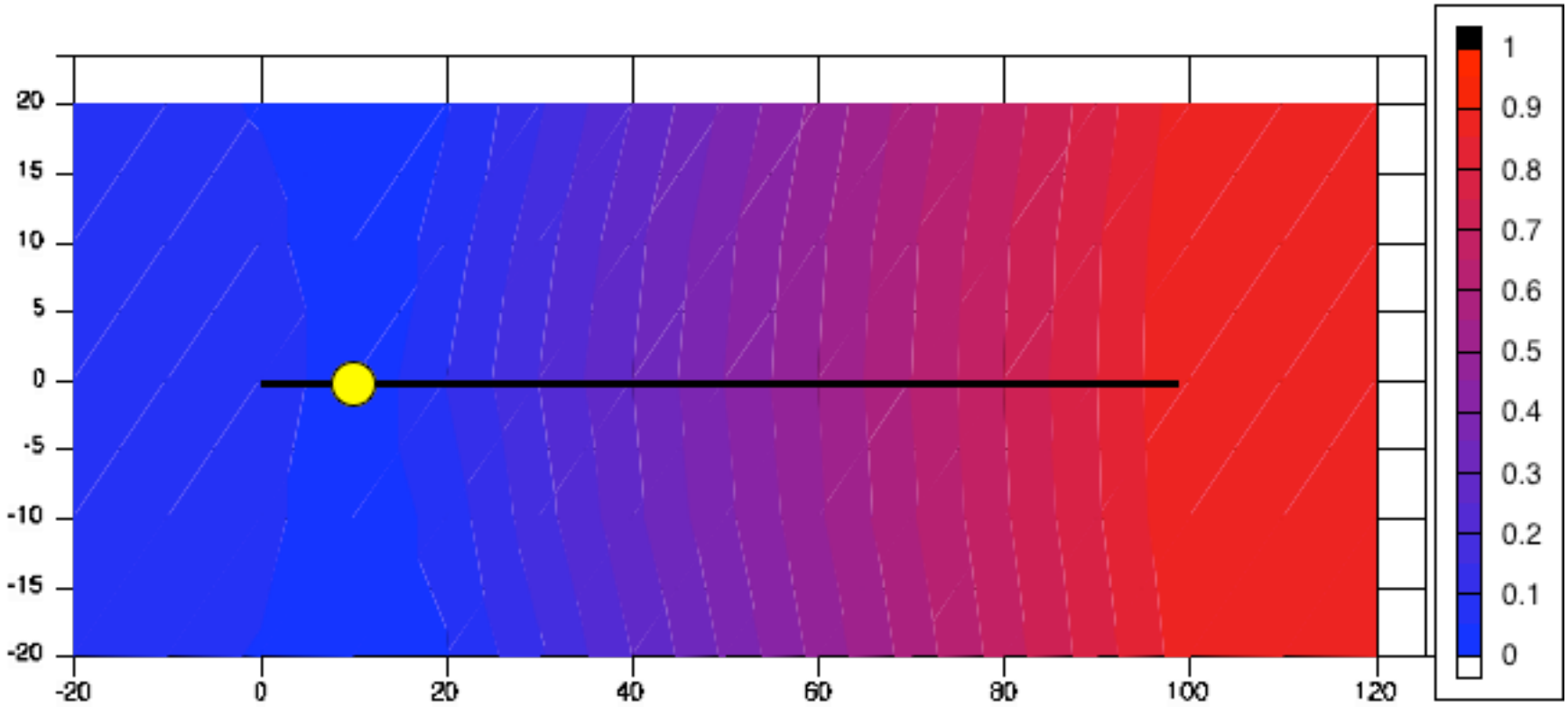
- Current directivity prediction parameters are dependent on hypocenter.
- Issues with randomization of hypocenters:
  - Large increase in calculation time
- Need a hypocenter independent predictive parameter.

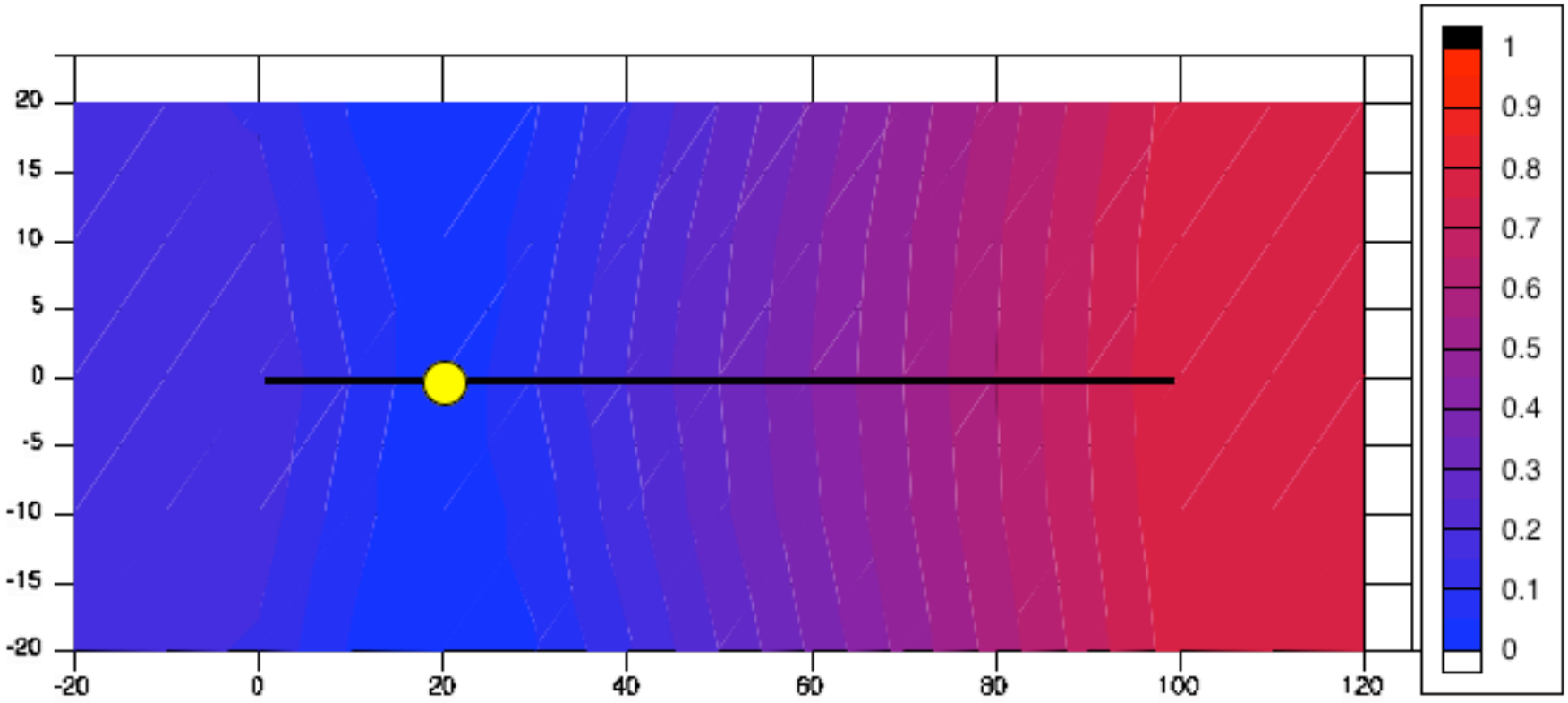
Development of hypocenter independent parameter

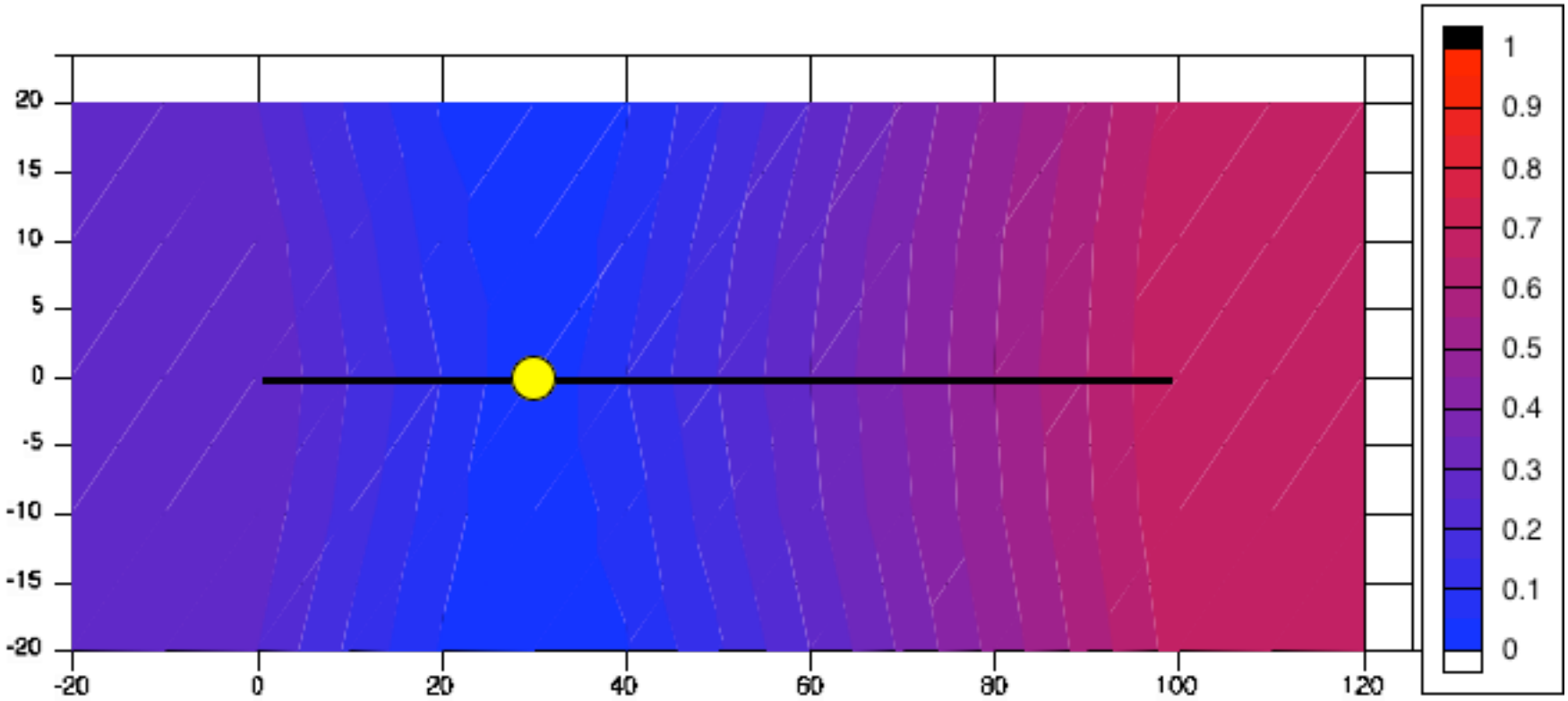
- What is the expected distribution of XcosTheta around a fault?

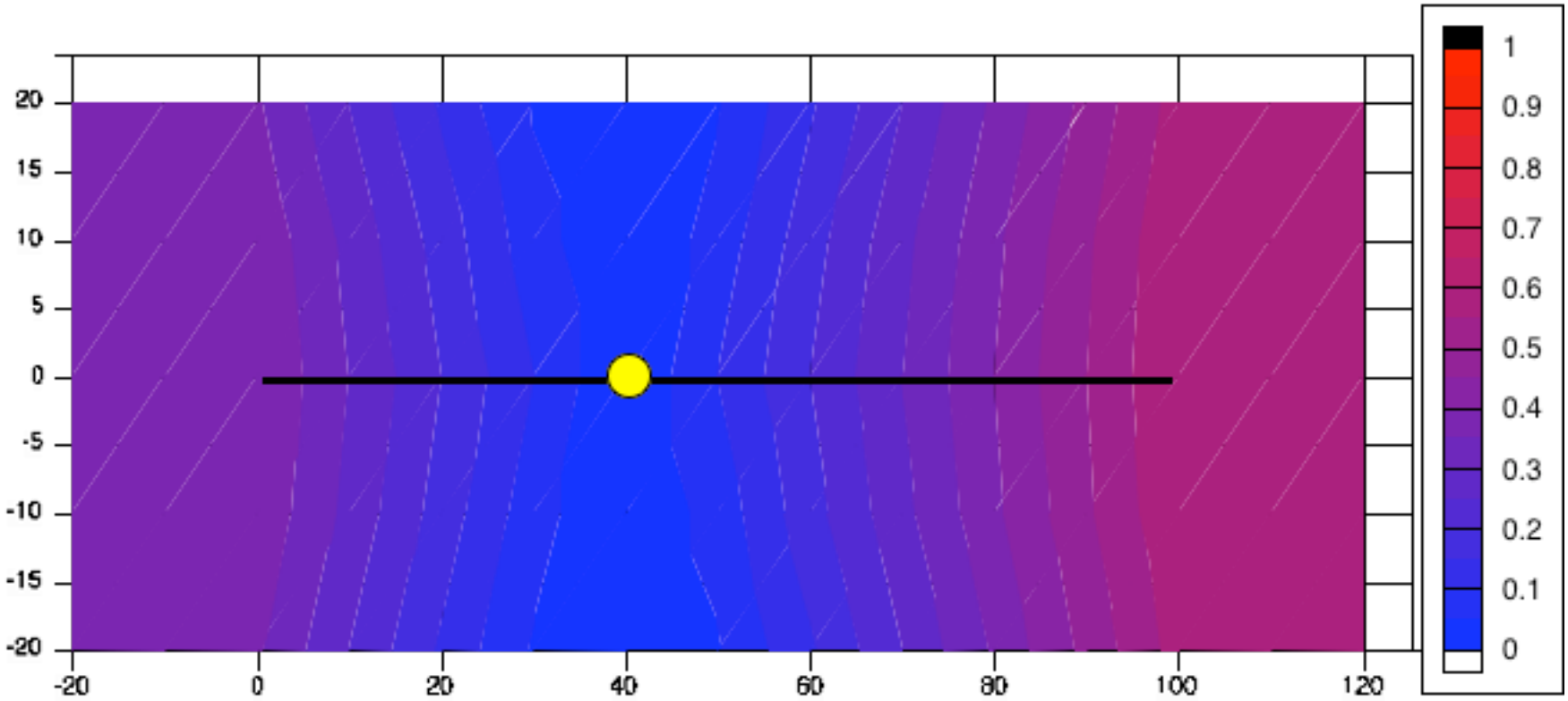
XcosTheta

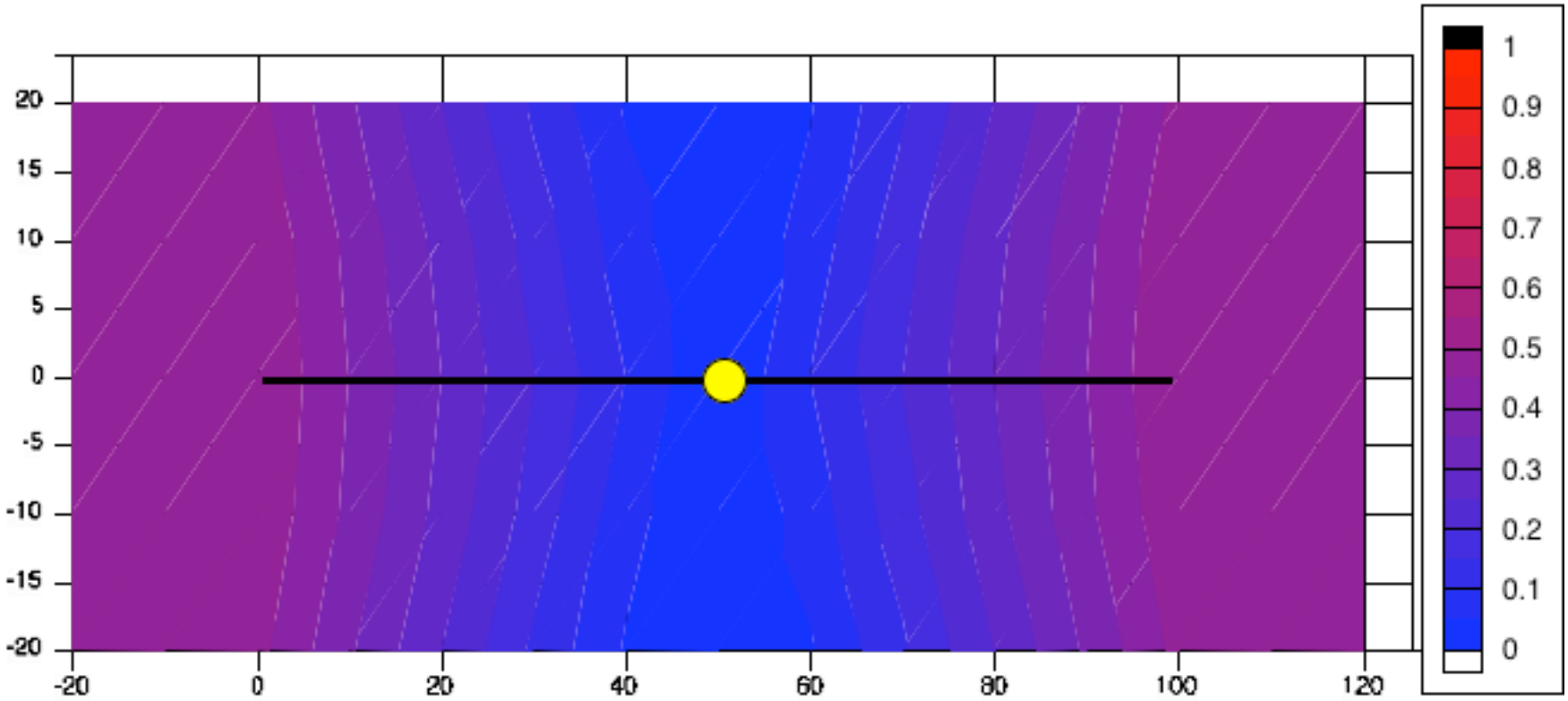

20
15
10
5
0
-5
-10
-15
-20
-20
0
20
40
60
80
100
120
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0

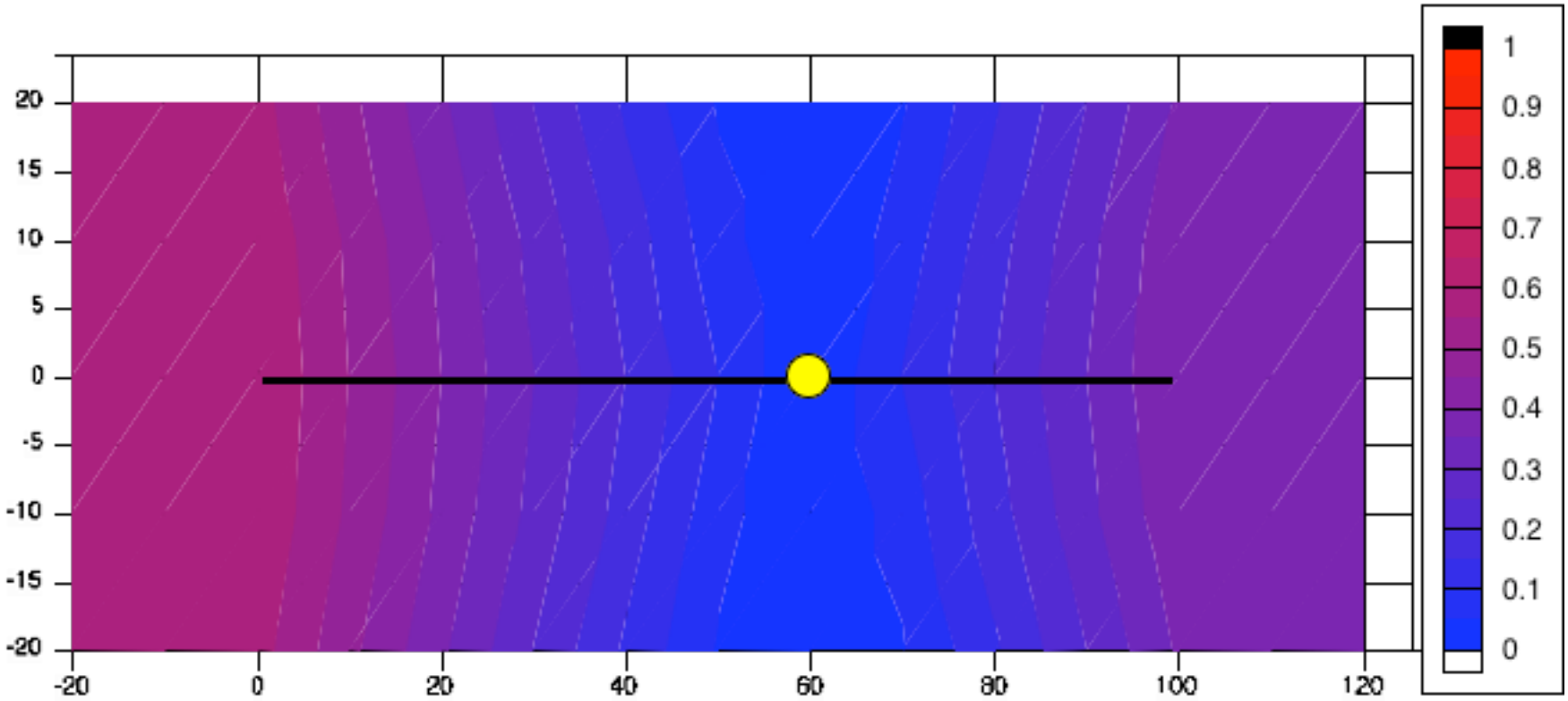

20
15
10
5
0
-5
-10
-15
-20
-20
0
20
40
60
80
100
120
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0

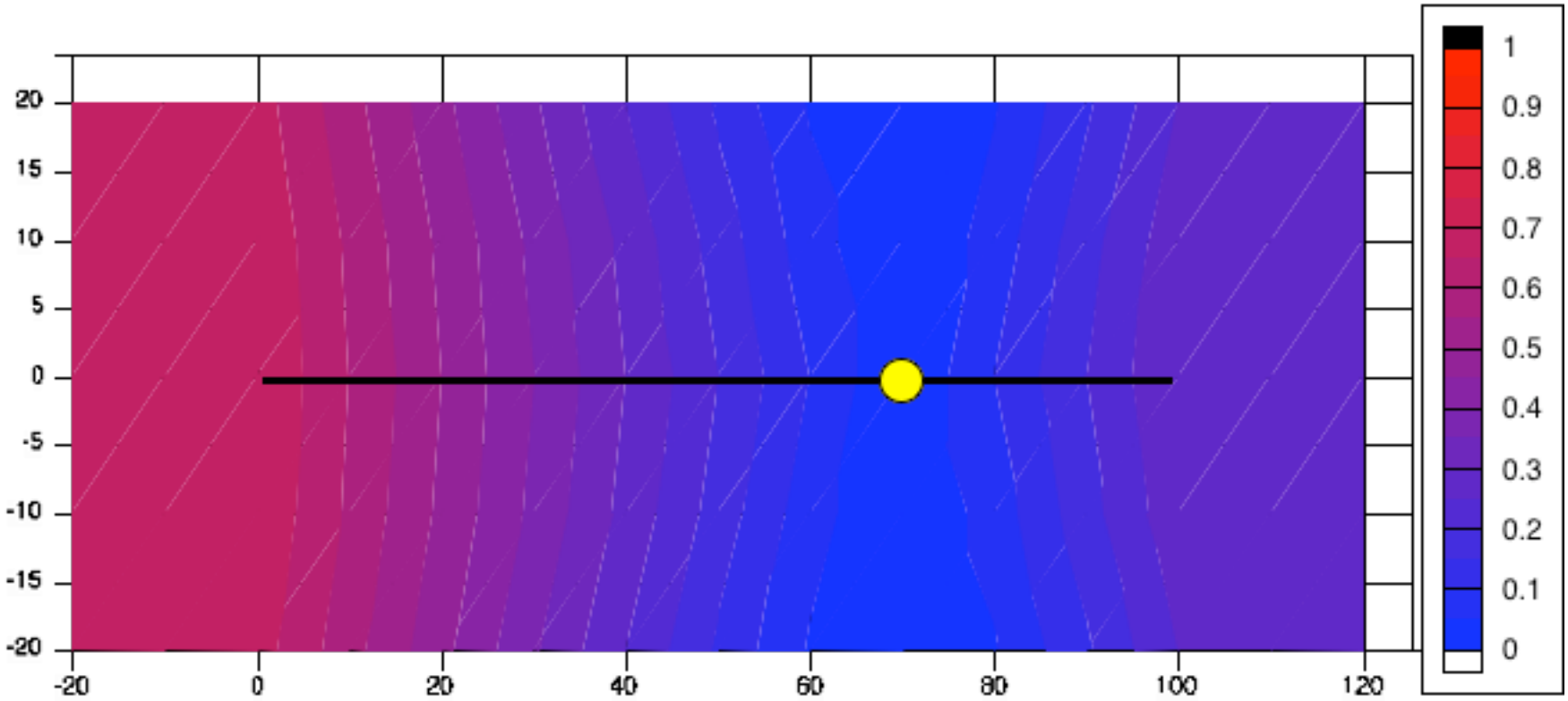

20
15
10
5
0
-5
-10
-15
-20
-20
0
20
40
60
80
100
120
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0

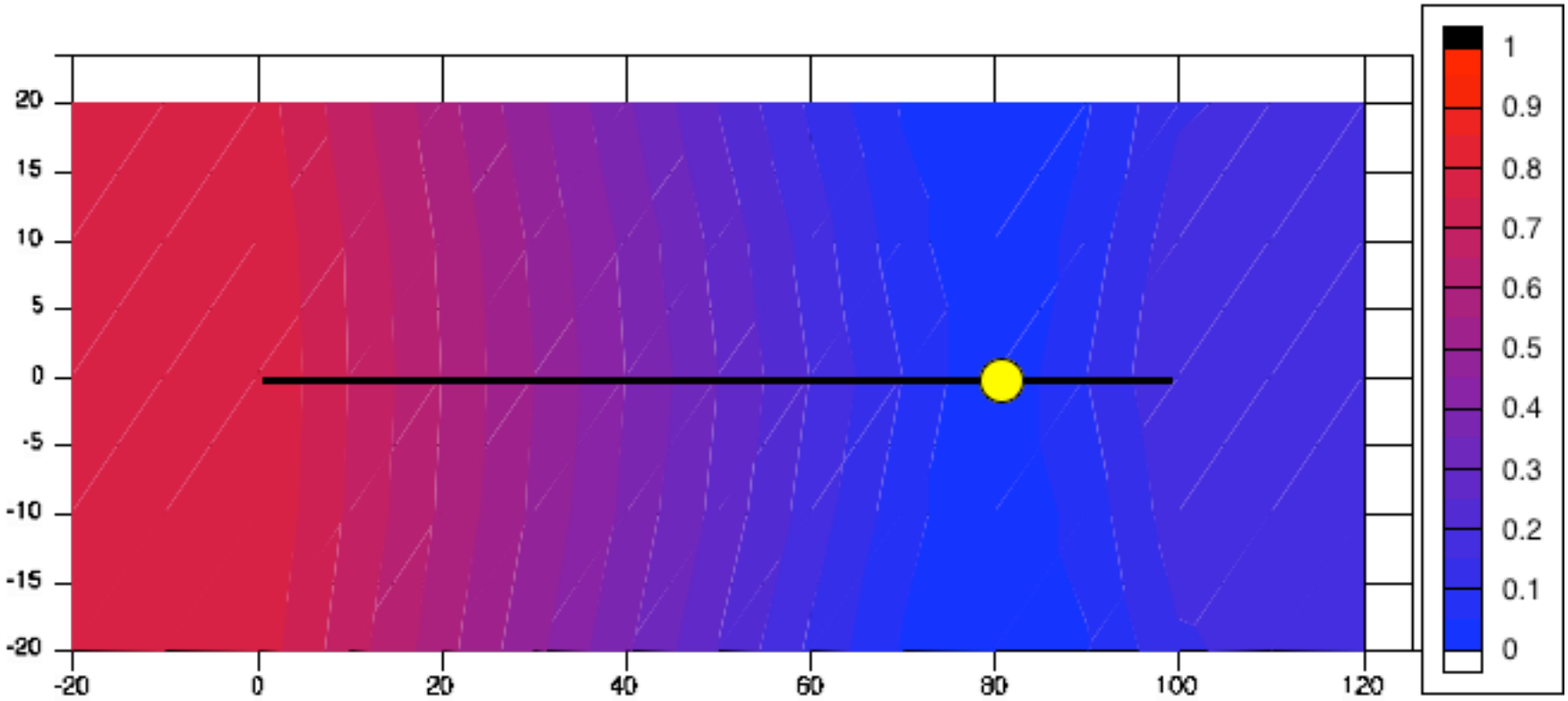

20
15
10
5
0
-5
-10
-15
-20
-20
0
20
40
60
80
100
120
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0

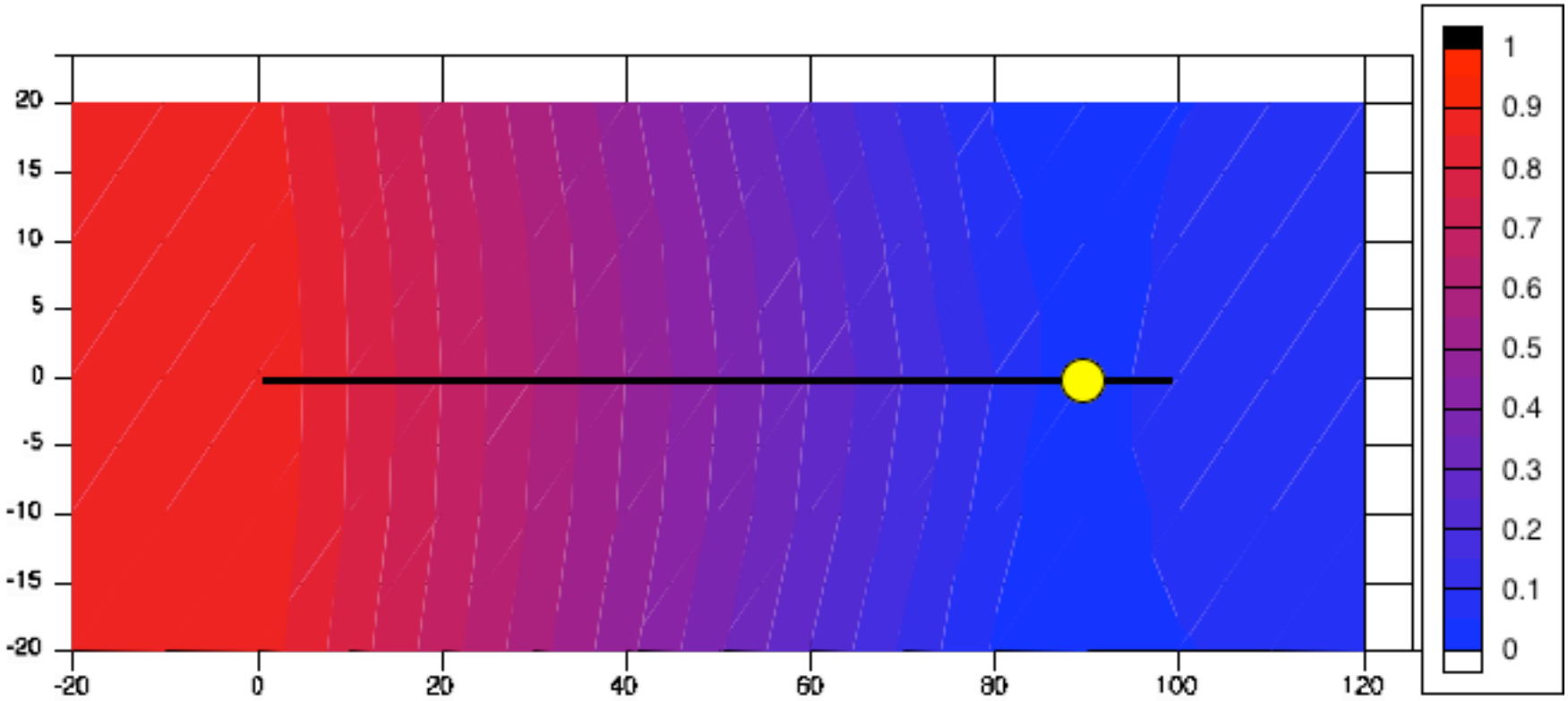

20
15
10
5
0
-5
-10
-15
-20
-20
0
20
40
60
80
100
120
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0

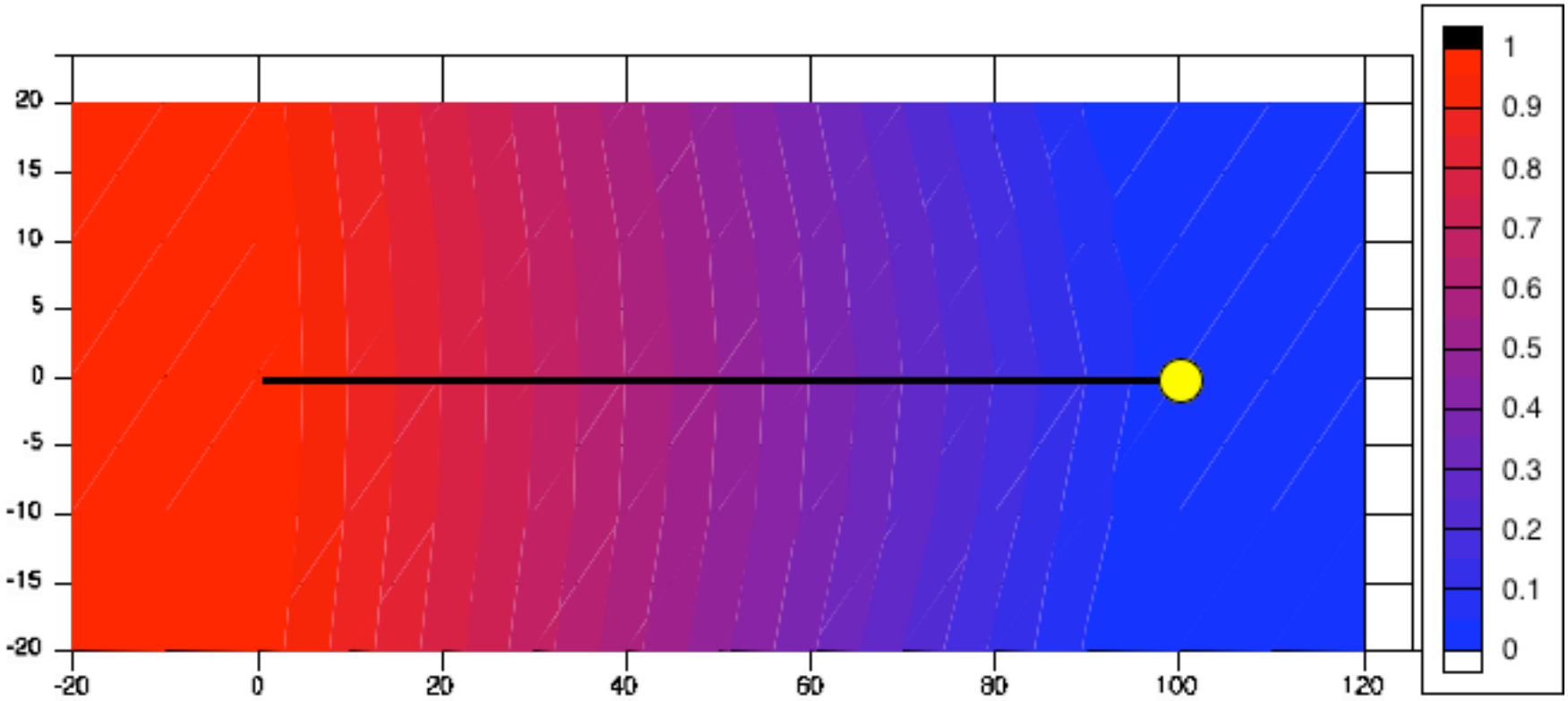

20
15
10
5
0
-5
-10
-15
-20
-20
0
20
40
60
80
100
120
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0


20
15
10
5
0
-5
-10
-15
-20
-20
0
20
40
60
80
100
120
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0

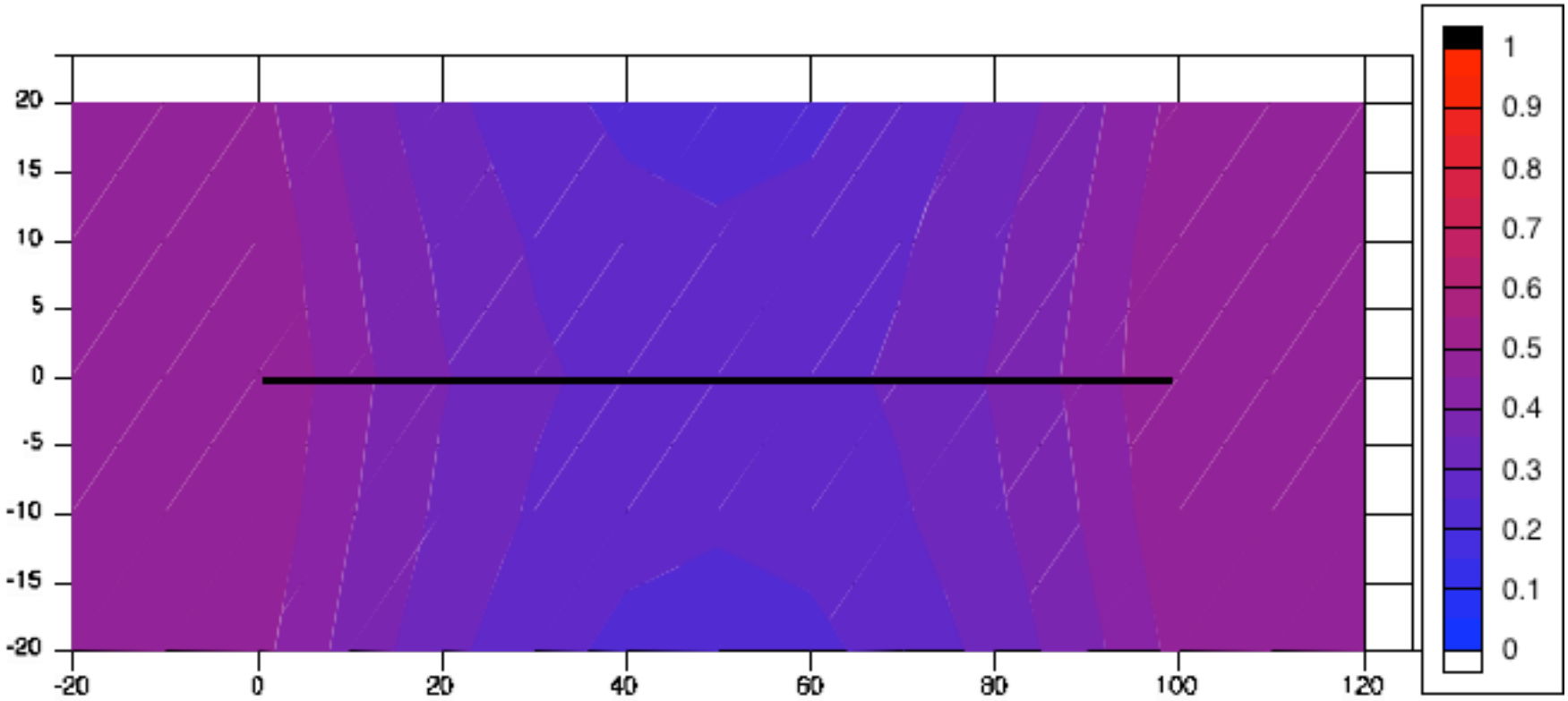

20
15
10
5
0
-5
-10
-15
-20
-20
0
20
40
60
80
100
120
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0


20
15
10
5
0
-5
-10
-15
-20
-20
0
20
40
60
80
100
120
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0

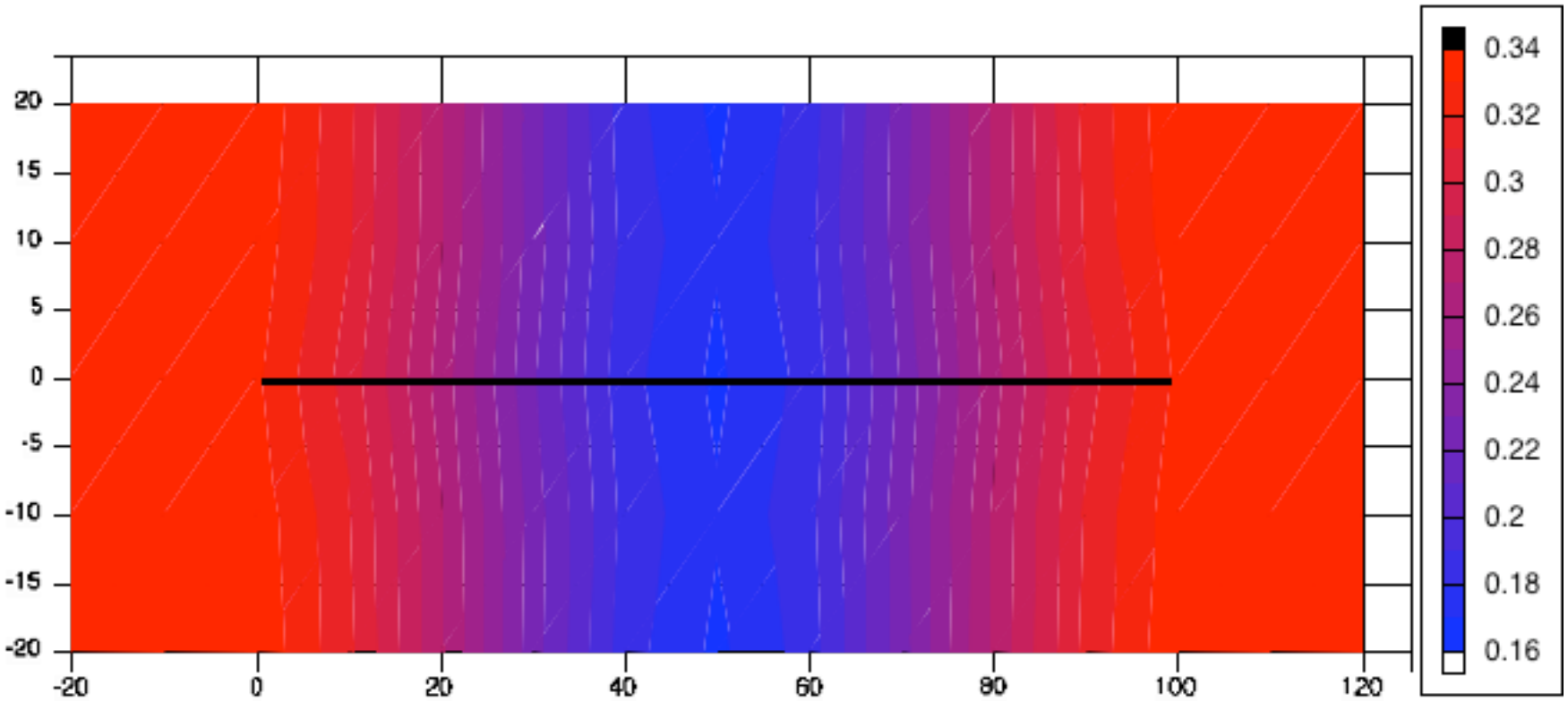

20
15
10
5
0
-5
-10
-15
-20
-20
0
20
40
60
80
100
120
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0


20
15
10
5
0
-5
-10
-15
-20
-20
0
20
40
60
80
100
120
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0

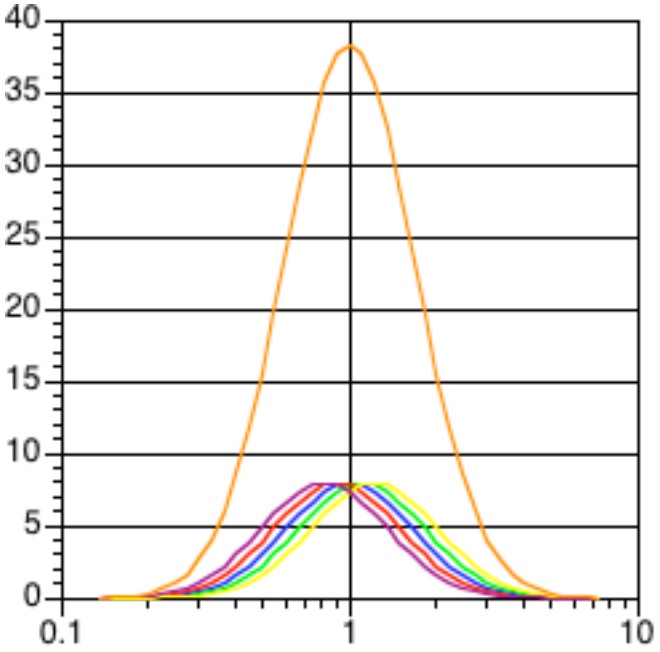
Average of XcosTheta



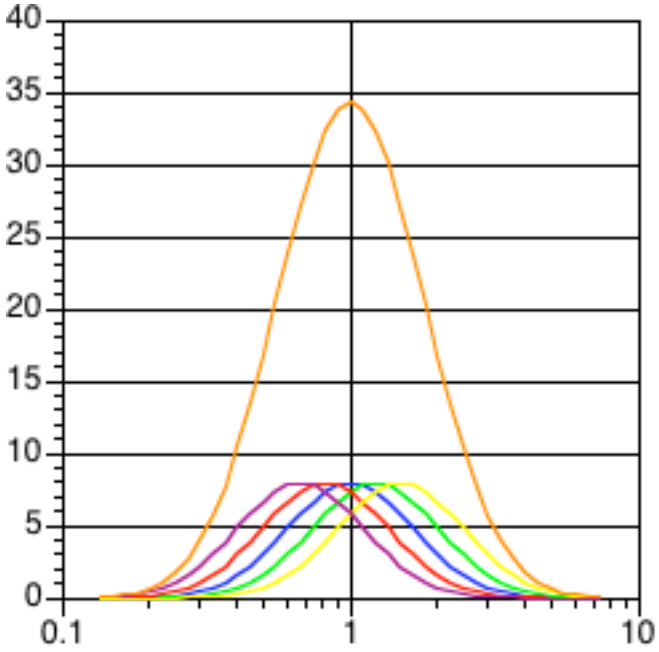
Standard Deviation of XcosTheta



Side of Fault -- Small variability in directivity parameter

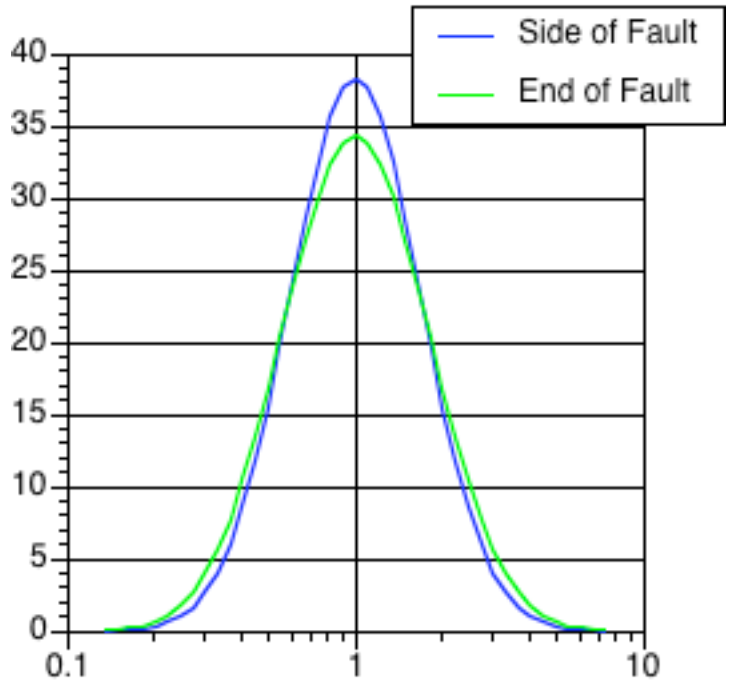


End of Fault -- Large variability in directivity parameter



Side of Fault -- Smaller Sigma

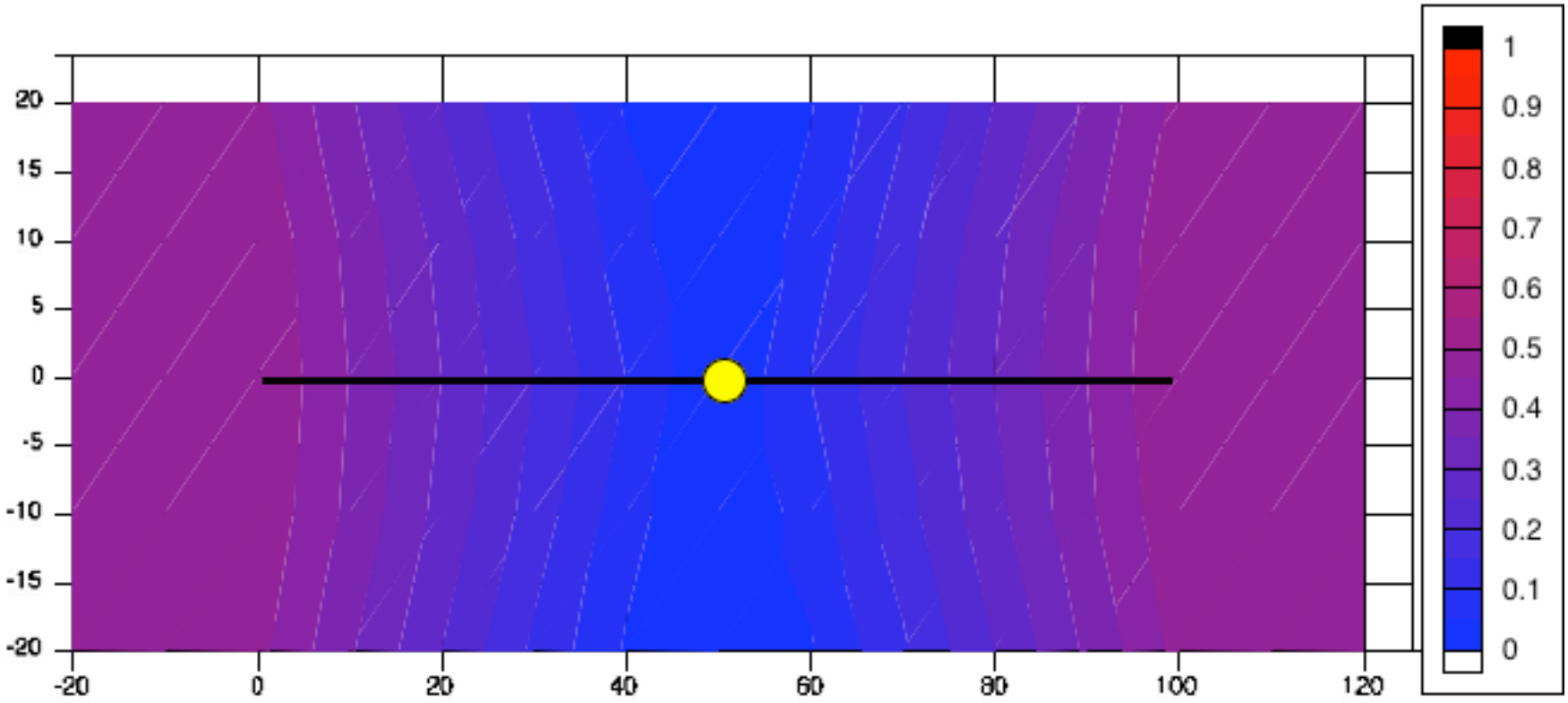
End of Fault -- Larger Sigma



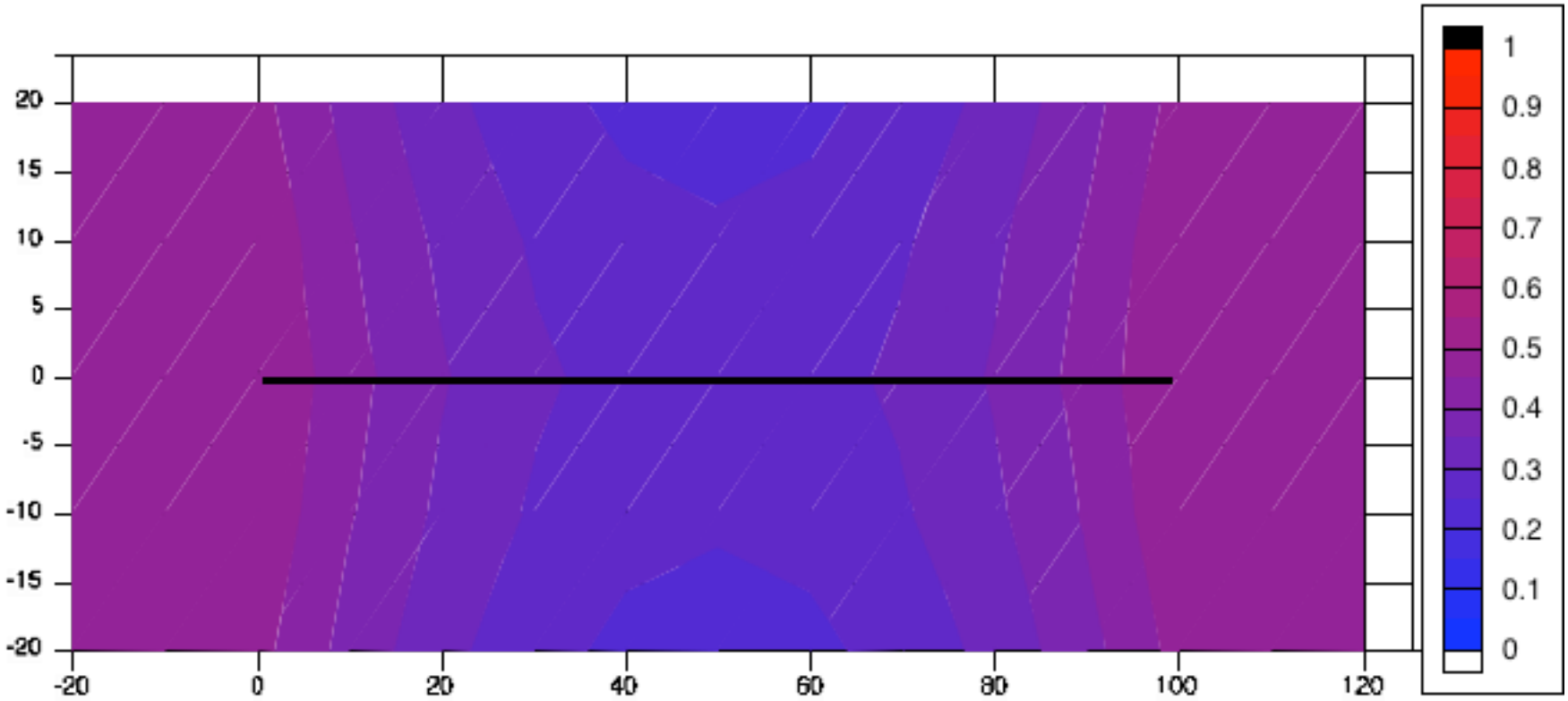
Development of hypocenter independent parameter

- What is the expected distribution of XcosTheta around a fault?
- Parameter:
  - Distance dependent sigma
  - Approximate XcosTheta

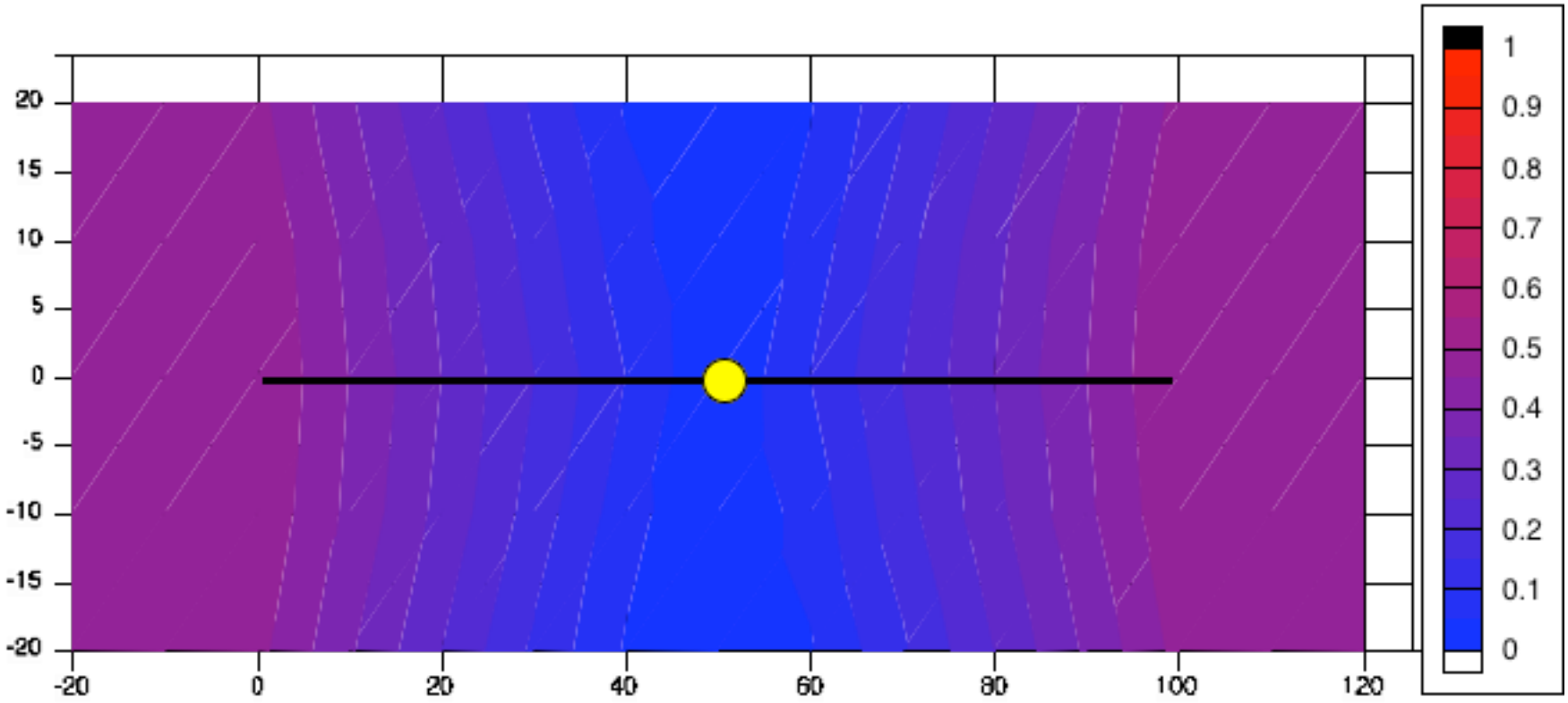
$XcosTheta_{center}$



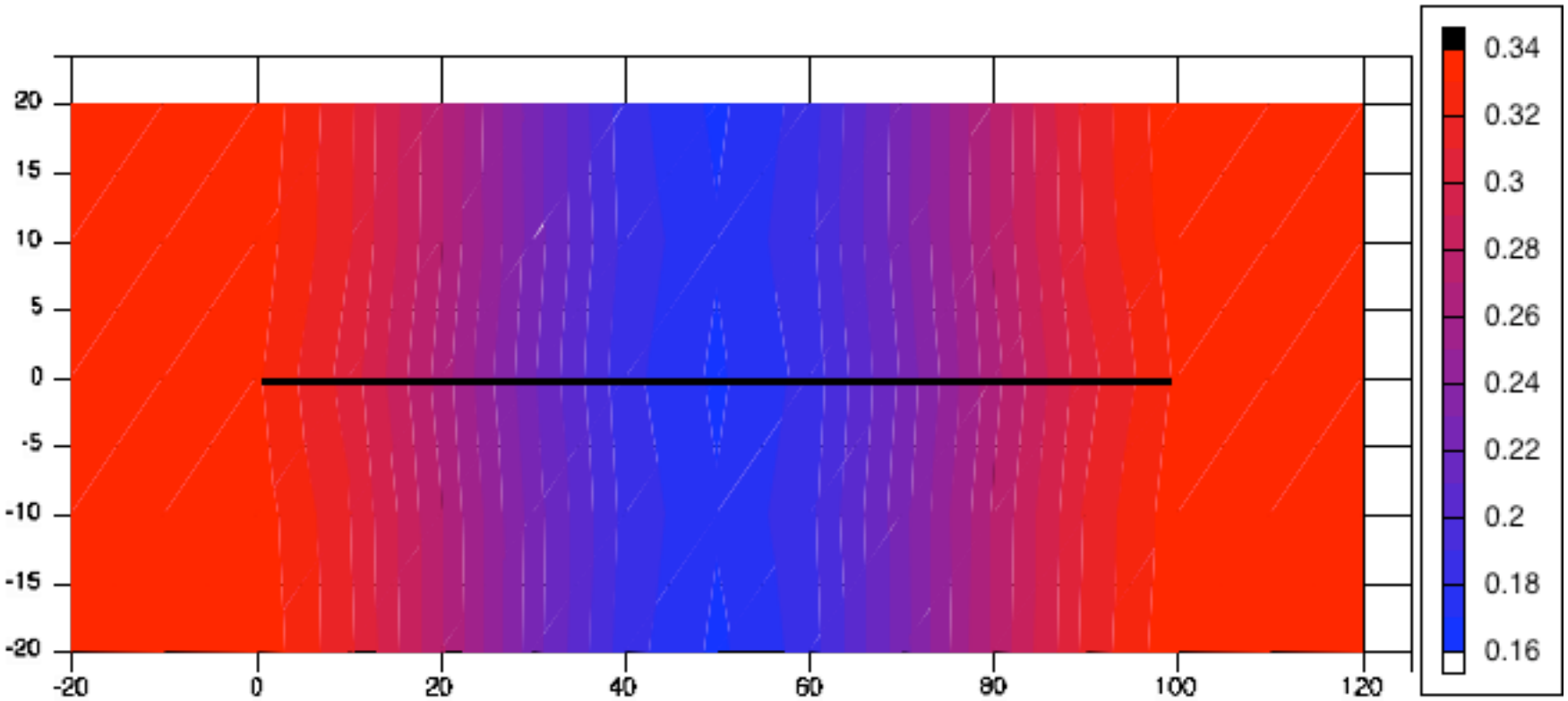
Average of XcosTheta



$XcosTheta_{center}$

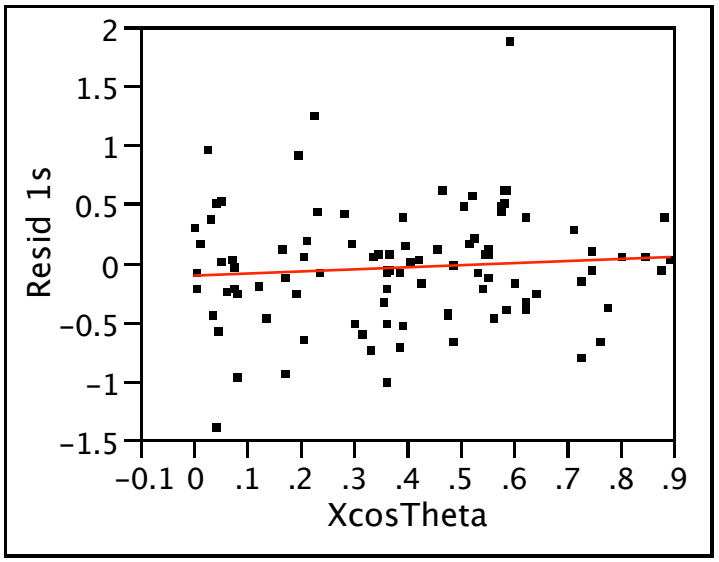


Standard Deviation of XcosTheta



Directivity Effects

- What is the magnitude of the effect when using a hypocenter dependent parameter? (XcosTheta)
- Using:
  - M > 6.5
  - Rrup < 50 km
  - SS
  - Within event residuals from Abrahamson & Silva 2006

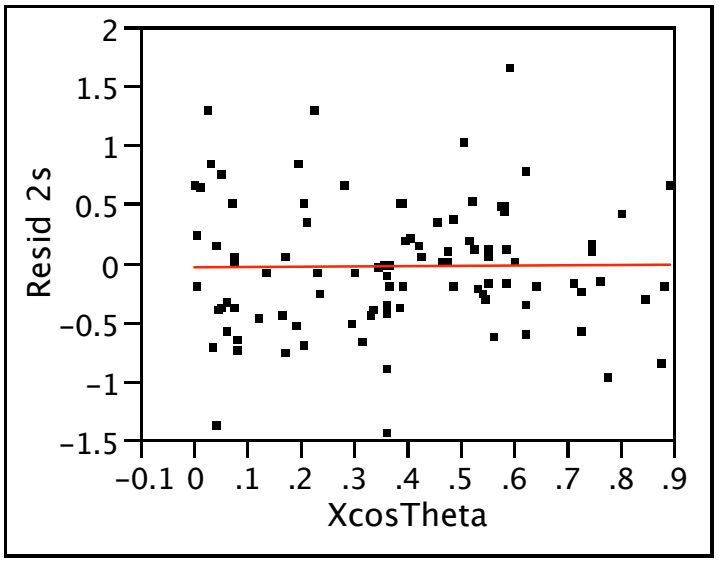


Summary of Fit

RSquare	0.006883
RSquare Adj	-0.00357
Root Mean Square Error	0.48719
Mean of Response	-0.03327
Observations (or Sum Wgts)	97

Parameter Estimates

Term	Estimate	Std Error	t Ratio	Prob>|t|
Intercept	-0.096239	0.092027	-1.05	0.2983
XcosTheta	0.1650159	0.203361	0.81	0.4191

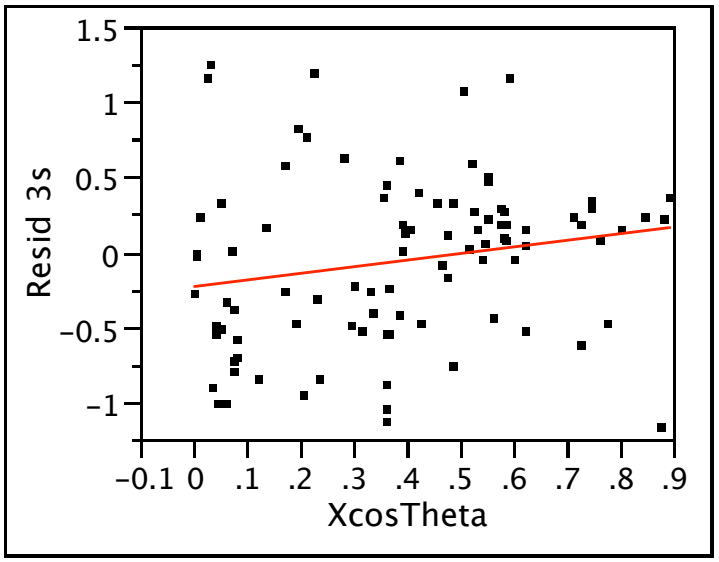


Summary of Fit

RSquare	0.000312
RSquare Adj	-0.01021
Root Mean Square Error	0.546544
Mean of Response	-0.02237
Observations (or Sum Wgts)	97

Parameter Estimates

Term	Estimate	Std Error	t Ratio	Prob>|t|
Intercept	-0.037352	0.103239	-0.36	0.7183
XcosTheta	0.0392527	0.228137	0.17	0.8638



Summary of Fit

RSquare	0.03847
RSquare Adj	0.027904
Root Mean Square Error	0.54753
Mean of Response	−0.05381
Observations (or Sum Wgts)	93

Parameter Estimates

Term	Estimate	Std Error	t Ratio	Prob>|t|
Intercept	−0.223191	0.105373	−2.12	0.0369
XcosTheta	0.4417499	0.231513	1.91	0.0595

Directivity Effects

- The effects of directivity on the rotation independent geometric mean (GMRotI) ground motion measure are small when using XcosTheta as a predictive parameter.
- Therefore, the difference in the median between the ends of the fault and the sides should be small and the increase in standard deviation at the end of the fault should be small.

Hypocenter Independent Directivity Effects

- Using:
  - M > 6.5
  - Rrup < 50 km
  - SS
  - Within event residuals from Abrahamson & Silva 2006

Hypocenter Independent Directivity Effects

- The difference in median between the ends of the fault and the sides is not statistically significant.
- Results of change in standard deviation
  - Sigma = $c_1 + c_2 * \text{XcosTheta}_{\text{center}}$

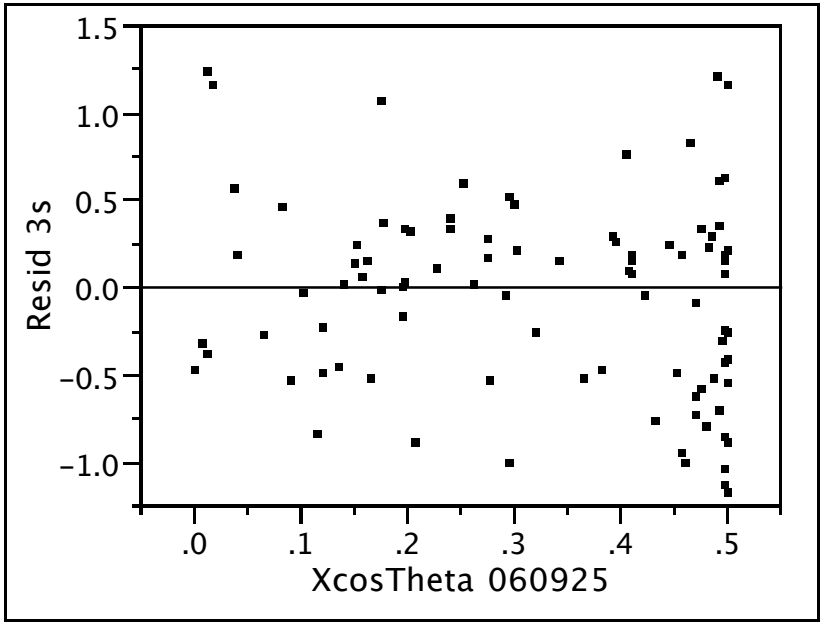
PSa (3 seconds)

.Solution

SSE	DFE	MSE	RMSE
-8.628965814	91	-0.094824	.

Parameter	Estimate	ApproxStdErr	Lower CL	Upper CL
a	0	0	.	.
b	0	0	.	.
c1	0.4970405653	0.07236043	.	.
c2	0.1738806453	0.19805593	.	.

Plot



Conclusions

- The effects of directivity are small in the new GrMPEs.
- They can be accommodated by using a spatially varying sigma without randomizing hypocenters.