SCEC/USGS Dynamic Rupture Benchmarks TPV36 and TPV37: Shallow Dip Thrust Fault

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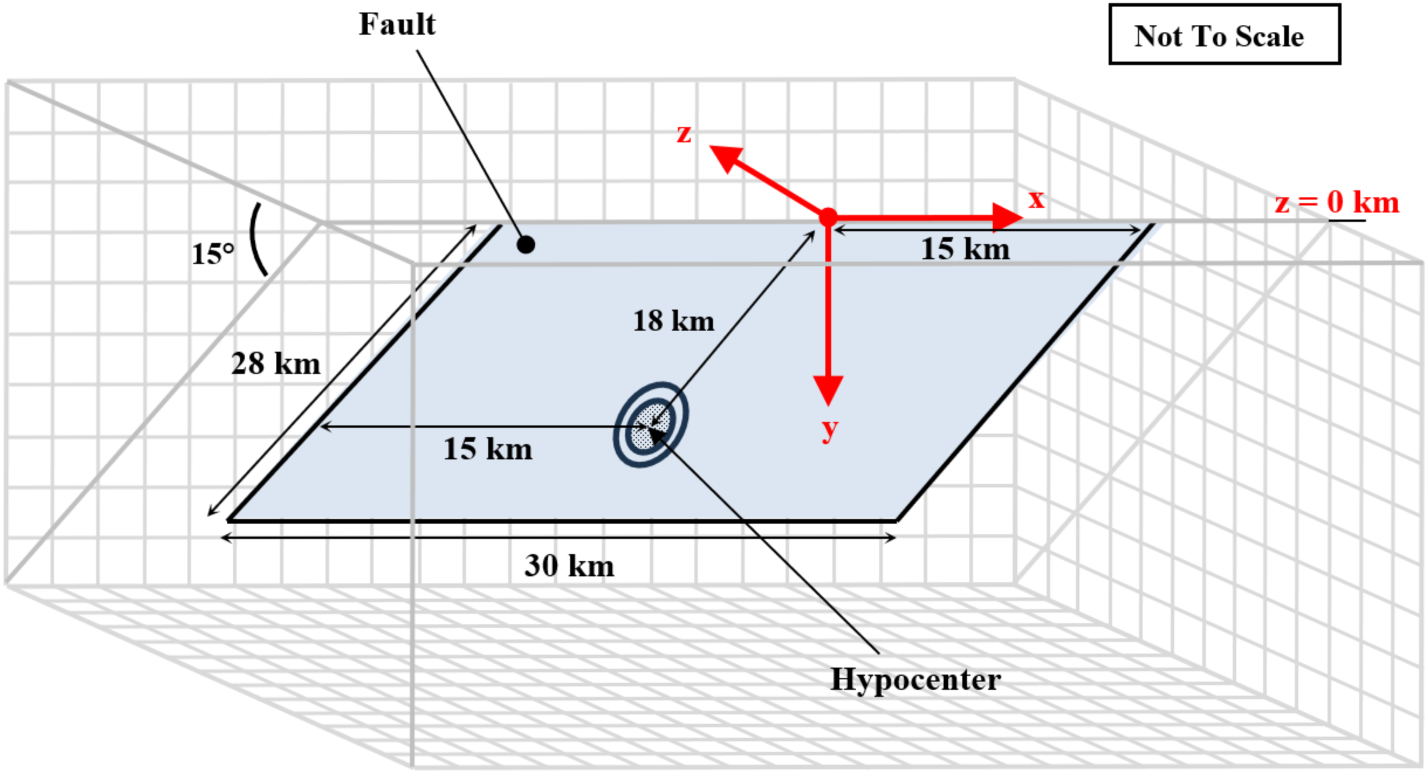
SCEC/USGS Dynamic Rupture Workshop
In collaboration with the CRESCENT DET Working Group
November 4, 2024



TPV36 and TPV37 Fault Geometry

- Dip angle 15 degrees.
- 30 km along strike.
- 28 km down-dip.
- Hypocenter 18 km down-dip.
- Fault reaches the Earth's surface.

Material Properties

- Uniform linear elastic half-space.
- Density: $\rho = 2670 \text{ kg/m}^3$
- S-wave speed: $V_s = 3464 \text{ m/s}$
- P-wave speed: $V_p = 6000 \text{ m/s}$

Initial Stress is Proportional to Depth

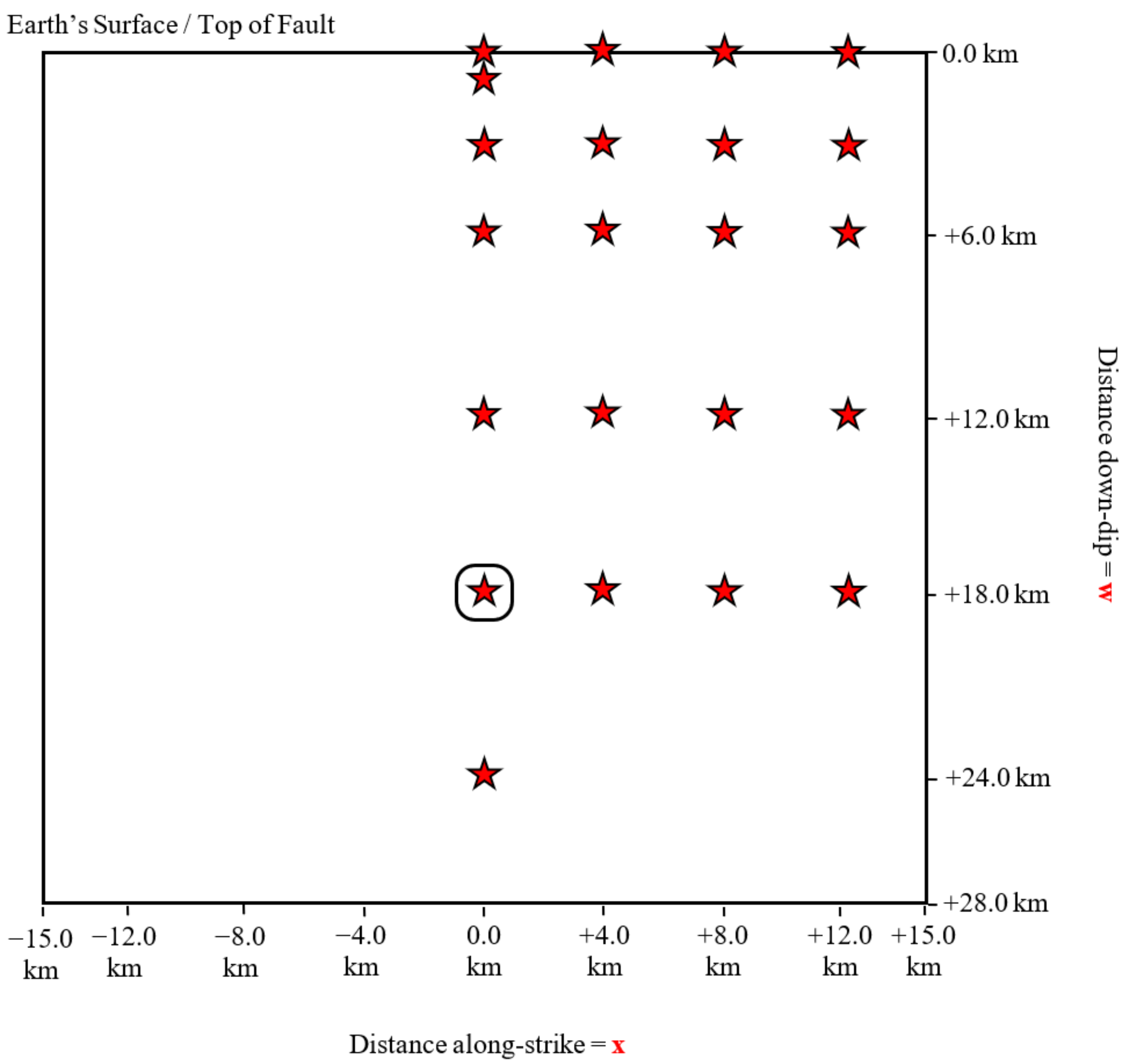
- Approximately lithostatic minus hydrostatic

Nucleation is by Time-Weakening

- Nucleation zone radius $r_{\text{crit}} = 4000 \text{ m}$

Linear Slip-Weakening Friction

- Static coefficient of friction: $\mu_s = 0.575$
- Dynamic coefficient of friction: $\mu_d = 0.450$
- Slip-weakening critical distance: $d_0 = 0.18 \text{ m}$
- Frictional cohesion at the Earth's surface: $C_0 = 4.0 \text{ MPa}$ (TPV36), $C_0 = 15.0 \text{ MPa}$ (TPV37), tapering to zero at 8 km down-dip
  - For TPV36, the cohesion allows the rupture to reach the Earth's surface.
  - For TPV37, the cohesion makes the rupture stop spontaneously before it reaches the Earth's surface.

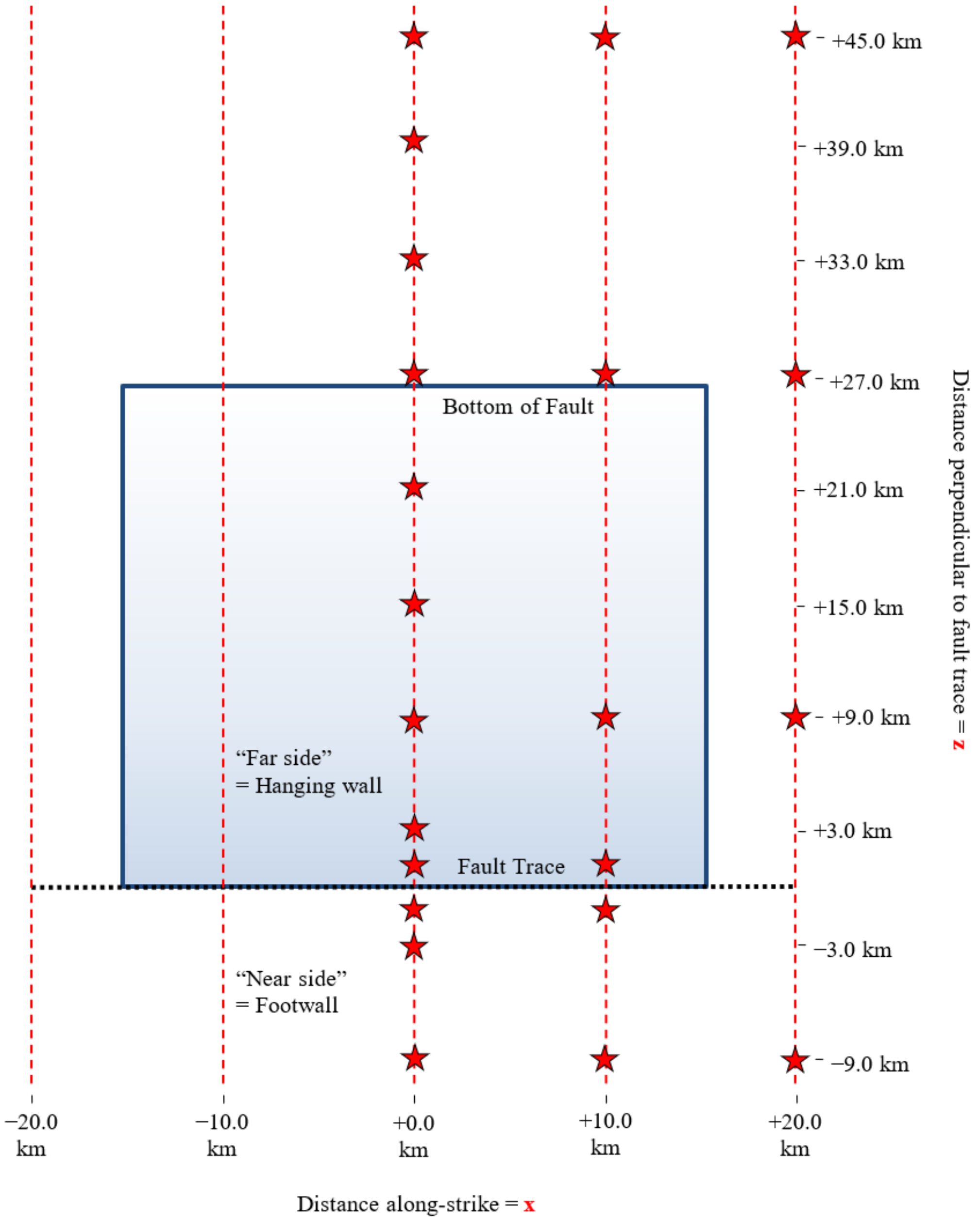


On-Fault Stations: Time Series Files

Each star is the location of a station on the fault.

For each station, modelers report the following as a function of time:

- Vertical and horizontal slip.
- Vertical and horizontal slip rate.
- Vertical and horizontal shear stress.
- Normal stress.



Off-Fault Stations: Time Series Files

Each star is the location of a station on the Earth's surface.

For each station, modelers report the following as a function of time:

- Three components of displacement.
- Three components of velocity.

The stations occupy a much larger area than the fault, to cover the area with significant uplift or subsidence.

Contour-Plot File

- Contains a list of points on the fault surface, and the time at which each point on the fault begins to slip.
- Modelers can choose their own list of points – the don’t have to form any particular pattern.
- Used by the website to make contour plots of the rupture front propagation.

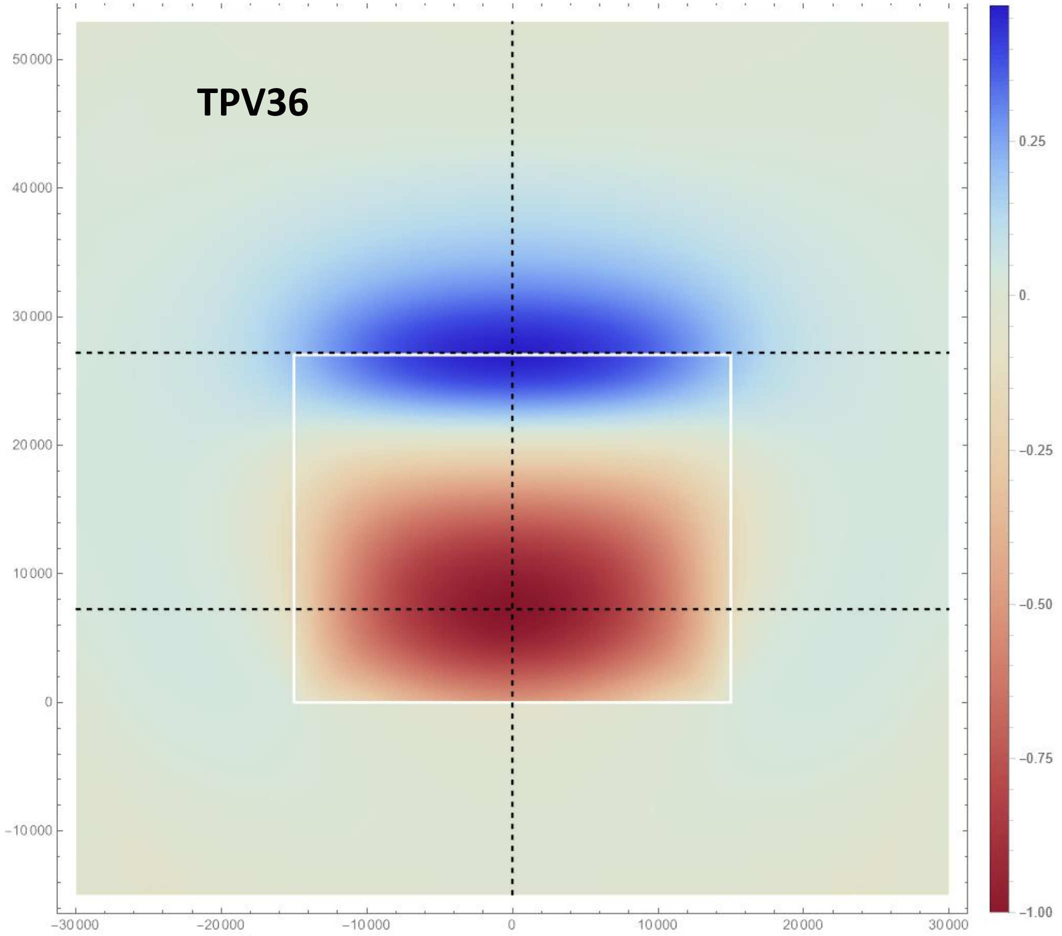
Surface Deformation File NEW!

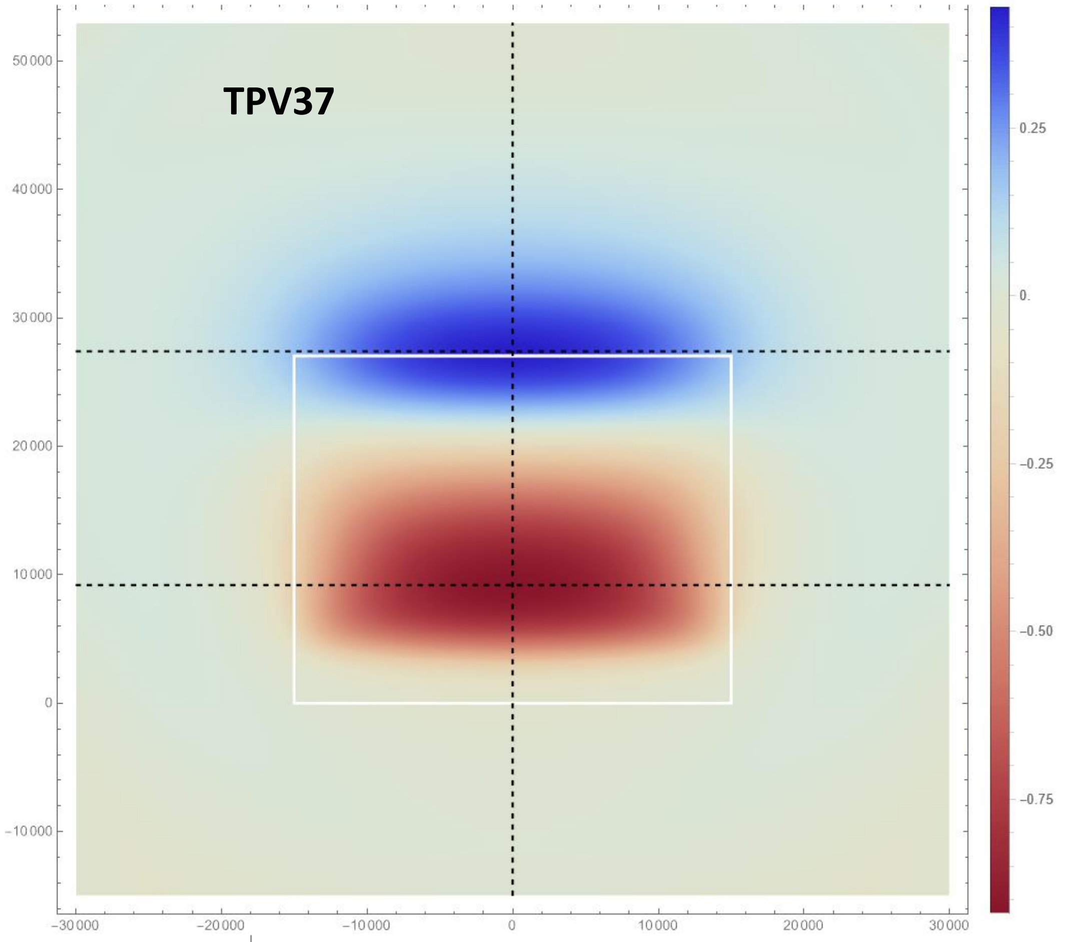
- Contains a list of points on the Earth’s surface, and the final displacement of each point at the end of the simulation.
- Modelers can choose their own list of points – the don’t have to form any particular pattern.
- Points cover an area measuring 60 km parallel to strike, and 68 km perpendicular to strike (much larger than the fault).
- Can be used to create a plot of uplift and subsidence.
- The website cannot handle the surface deformation file.

Metrics

- From the modeler’s files, we compute quantitative metrics, comparing every pair of time-series and every pair of contour plots.
- We also compute summaries that offer quantitative overviews of how well the modelers agree with each other.

Surface Deformation Plots



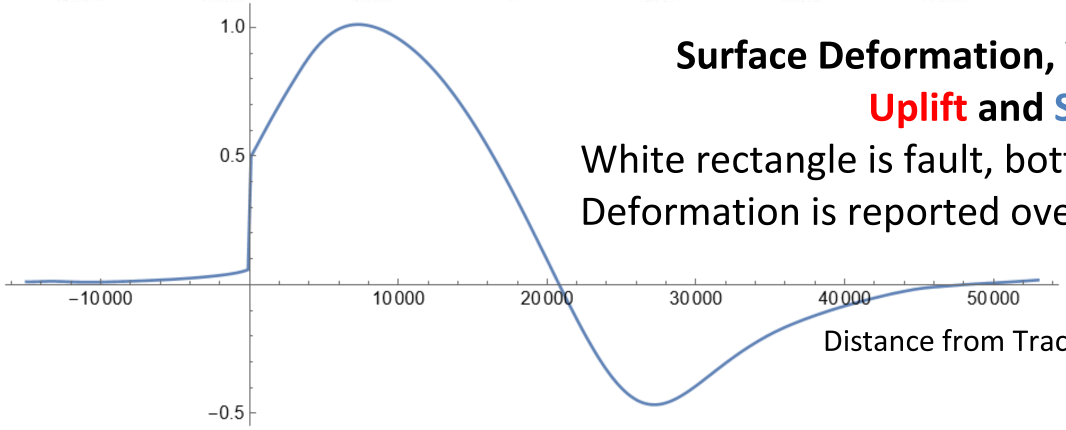


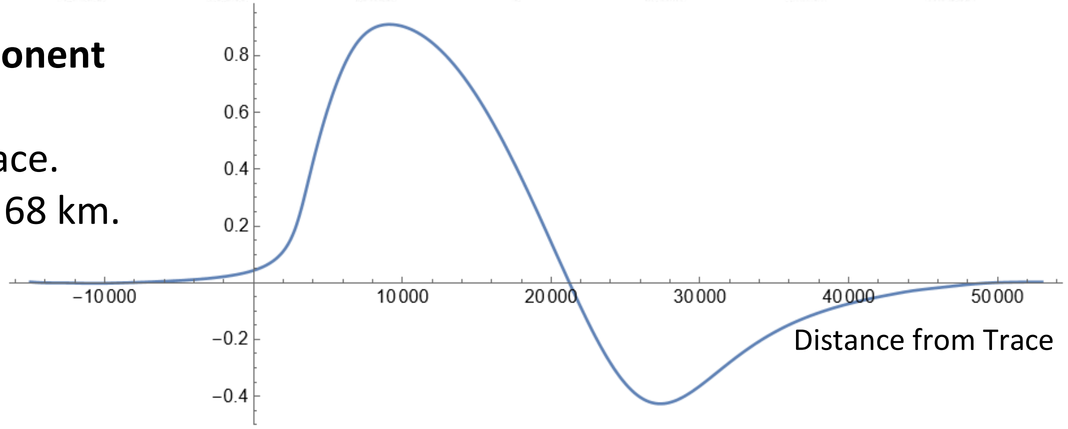
Surface Deformation, Vertical Component

Uplift and Subsidence

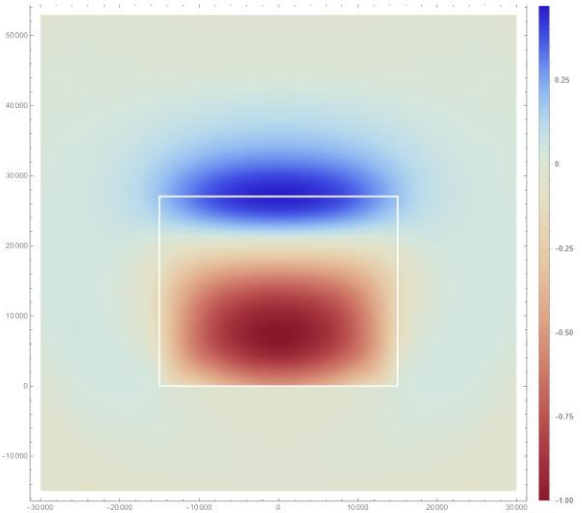
White rectangle is fault, bottom edge is trace.

Deformation is reported over an area 60 x 68 km.

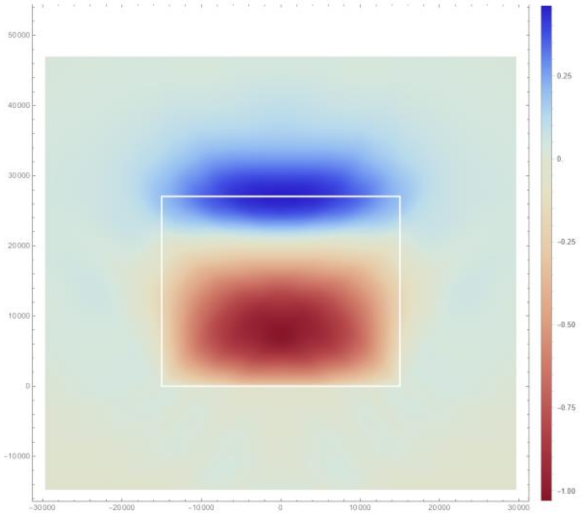




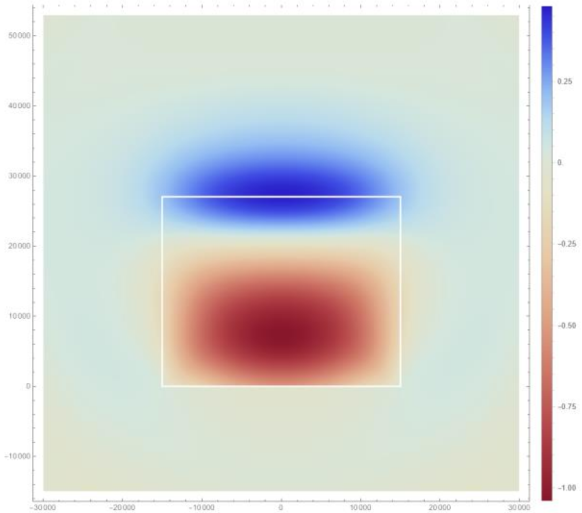
TPV36 Surface Deformation – Vertical Component



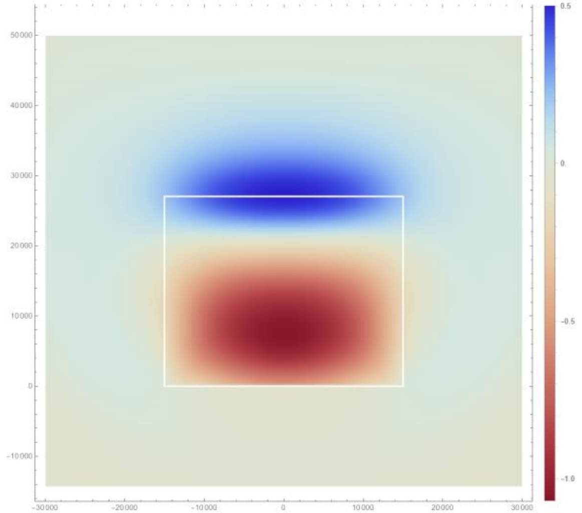
barall (FaultMod)



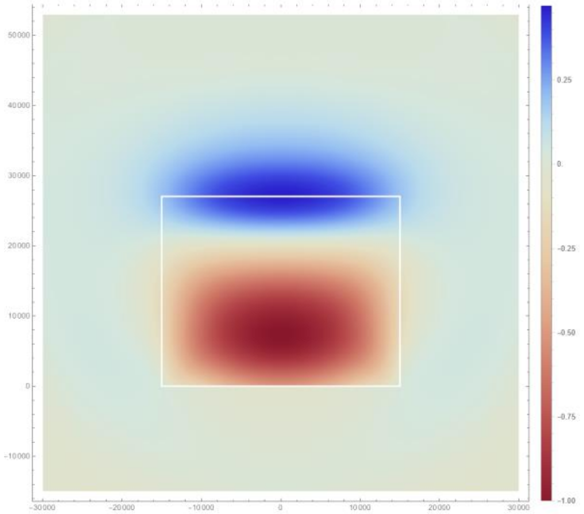
dliu.2 (EQDyna)



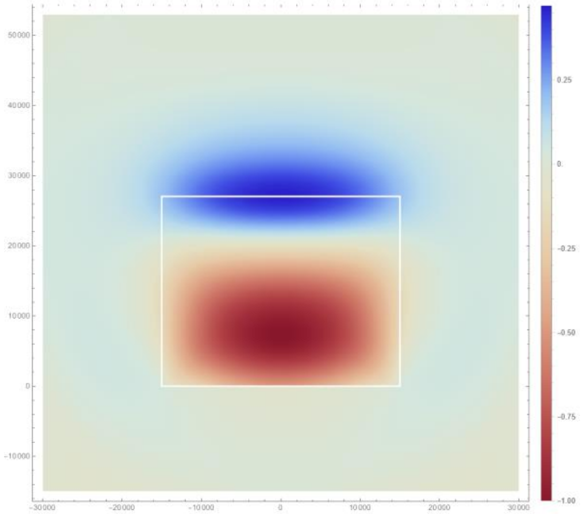
kutschera.2 (SeisSol)



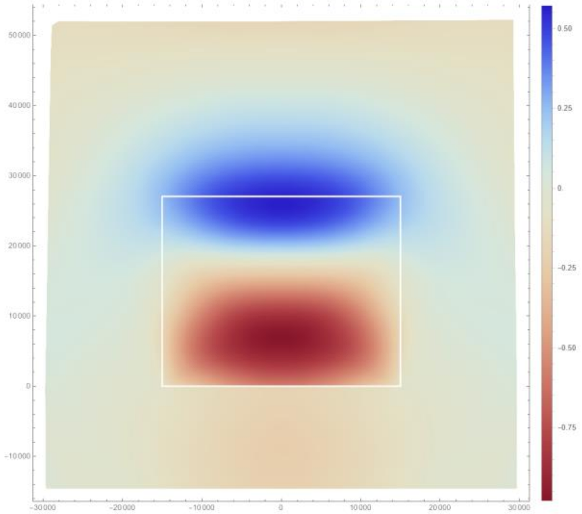
li.2 (SeisSol)



ma (MAFE)



wzhang (Mixed-Flux DG)



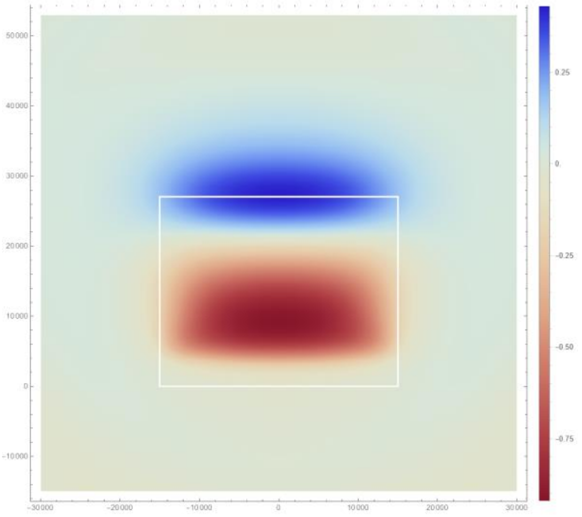
yang (PyLith)

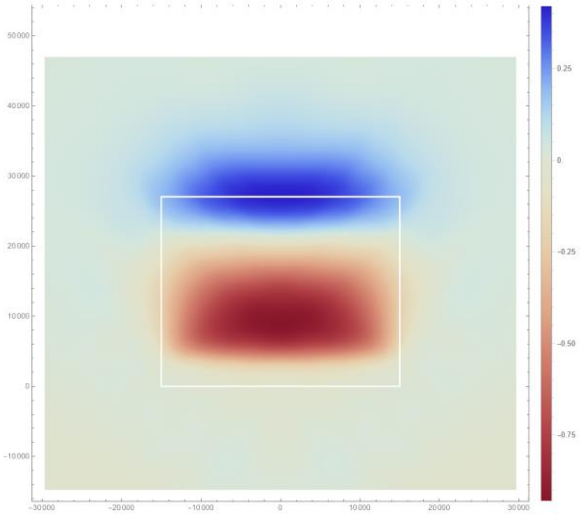
White rectangle is the fault. Bottom edge of the rectangle is the fault trace.

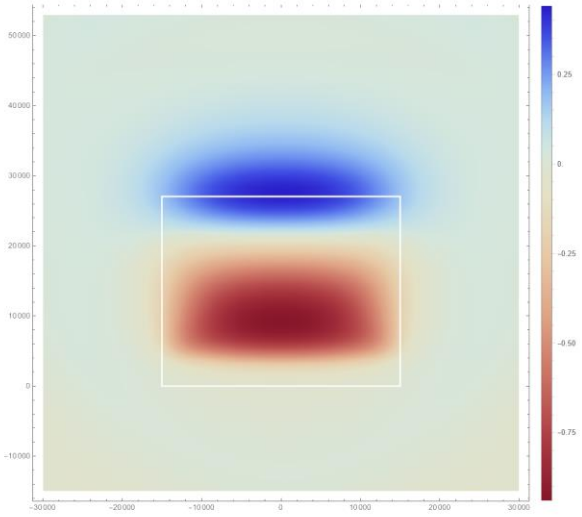
Red is uplift.

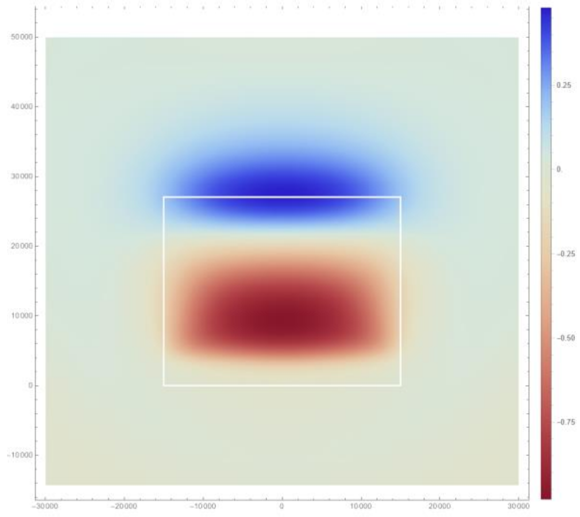
Blue is subsidence

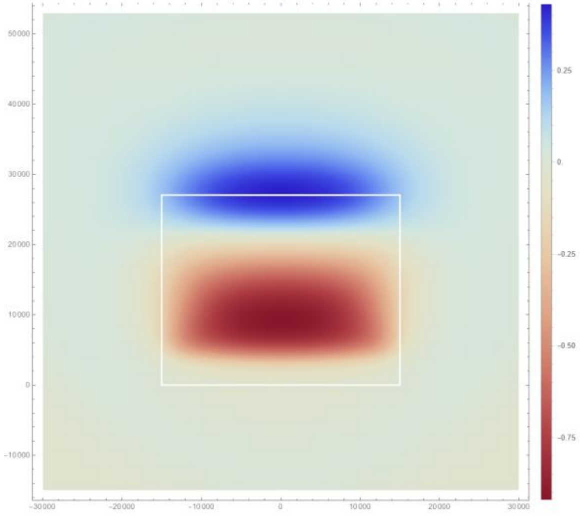
TPV37 Surface Deformation – Vertical Component

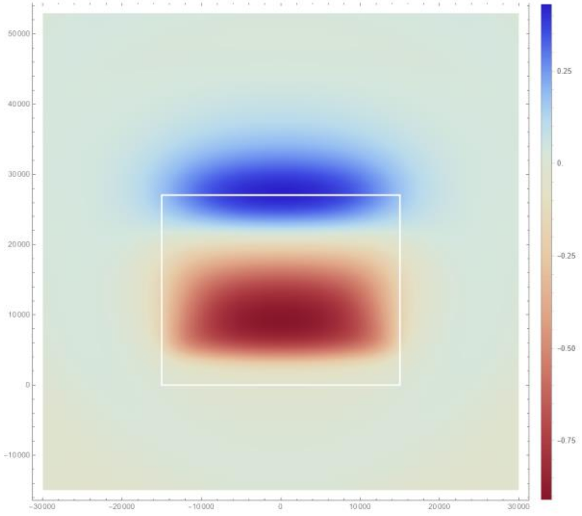

barall (FaultMod)

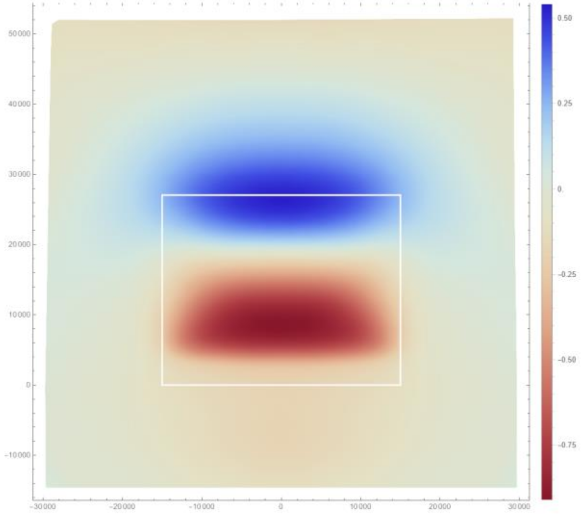

dliu (EQDyna)


kutschera.2 (SeisSol)


li (SeisSol)


ma (MAFE)


wzhang (Mixed-Flux DG)


yang (PyLith)

White rectangle is the fault. Bottom edge of the rectangle is the fault trace.

Red is uplift.

Blue is subsidence

Peak Uplift and Subsidence

TPV36

User	*Max Uplift (m)*	*Max Subsidence (m)*
barall	1.021	0.469
dliu.2	1.031	0.462
kutschera.2	1.039	0.476
li.2	1.069	0.525
ma	1.020	0.470
wzhang	1.011	0.470
yang	0.982	0.569

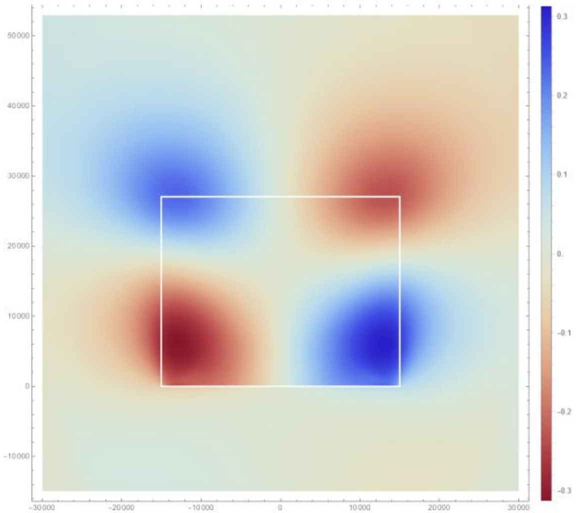
barall (Michael Barall - FaultMod - 50 m)
dliu.2 (EQdyna.v5.3.3.50m.dliu)
kutschera.2 (Fabian Kutschera - DG - SeisSol v1.2.0 - fault 200 m - o4)
li.2 (Duo Li - DG FE,h=200m, O4)
ma (Shuo Ma - Finite Element - MAFE - 50 m on fault)
wzhang (Wenqiang Zhang - Mixed-Flux DG (200m~10km, O4))
yang (Hongfeng Yang - Finite Element - PyLith)

TPV37

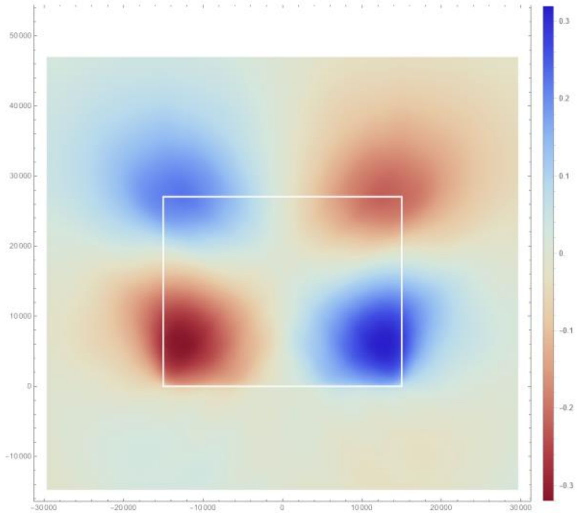
User	*Max Uplift (m)*	*Max Subsidence (m)*
barall	0.920	0.430
dliu	0.928	0.425
kutschera.2	0.936	0.437
li	0.977	0.482
ma	0.920	0.431
wzhang	0.914	0.431
yang	0.913	0.536

barall (Michael Barall - FaultMod - 50 m)
dliu (EQdyna.v5.3.3.50m.dliu)
kutschera.2 (Fabian Kutschera - DG - SeisSol v1.2.0 - fault 200 m - o4)
li (Duo Li - DG, h200,o4)
ma (Shuo Ma - Finite Element - MAFE - 50 m on fault)
wzhang (Wenqiang Zhang - Mixed-Flux DG (200m~10km, O4))
yang (Hongfeng Yang - Finite Element - PyLith)

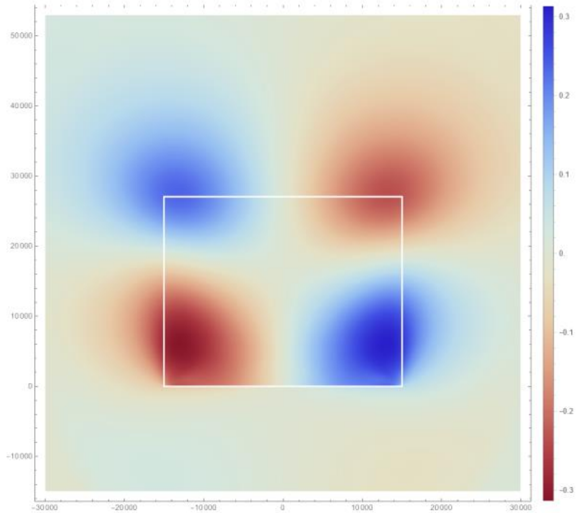
TPV36 Surface Deformation – Horizontal Component (Parallel to the Fault Trace)



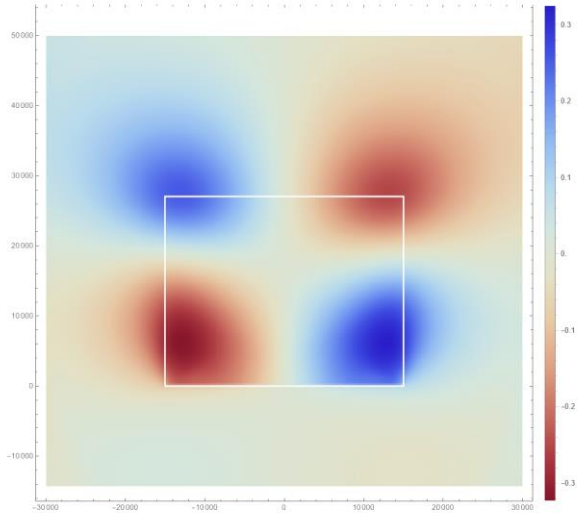
barall (FaultMod)



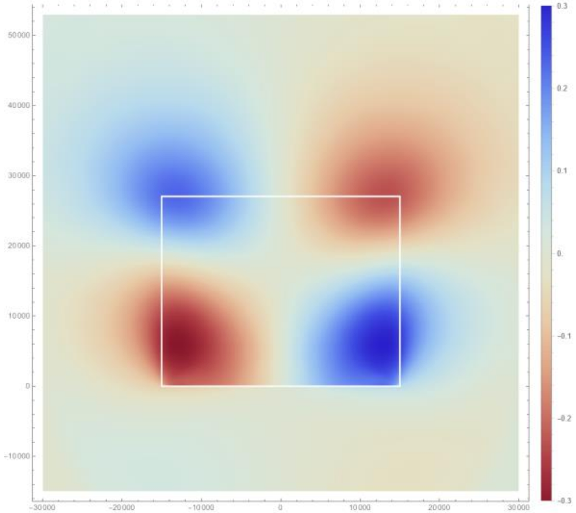
dliu.2 (EQDyna)



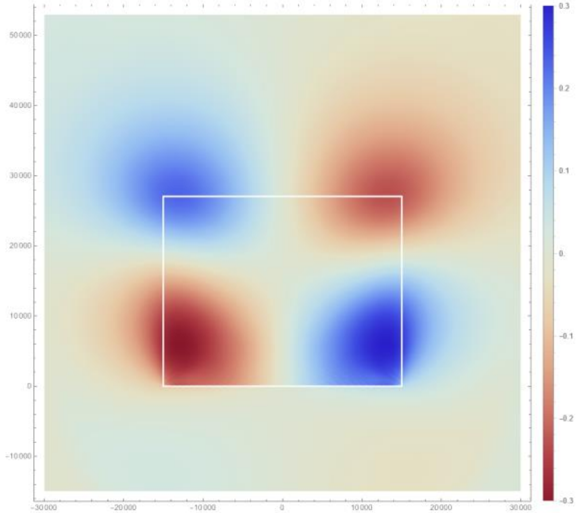
kutschera.2 (SeisSol)



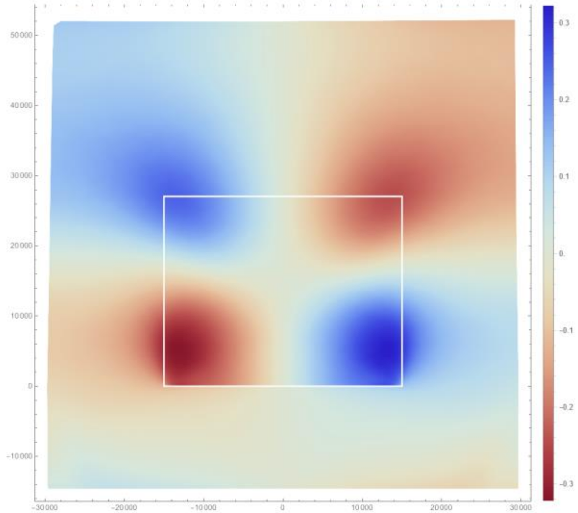
li.2 (SeisSol)



ma (MAFE)



wzhang (Mixed-Flux DG)



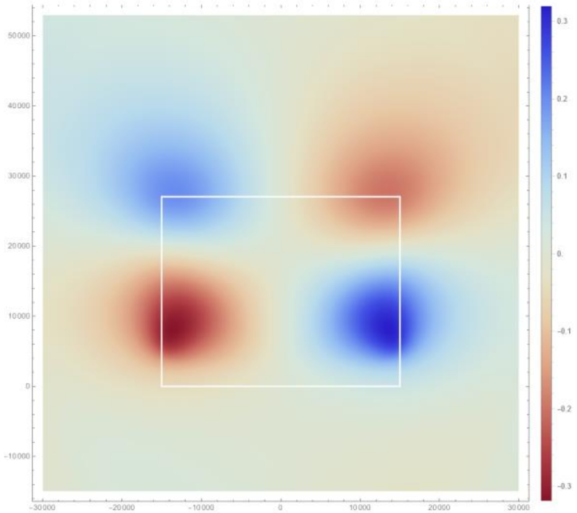
yang (PyLith)

White rectangle is the fault. Bottom edge of the rectangle is the fault trace.

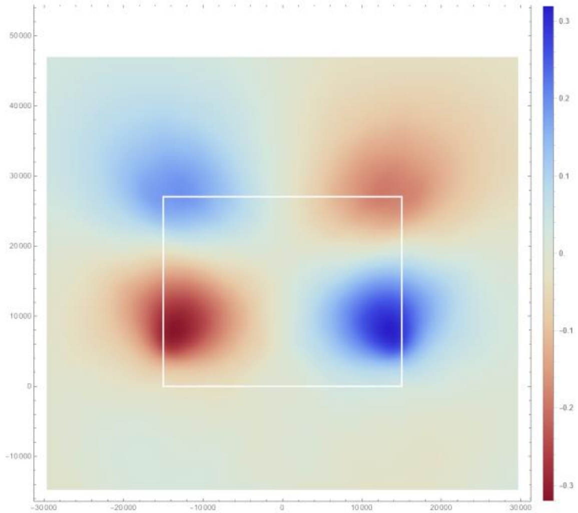
Red is displacement to the left.

Blue is displacement to the right

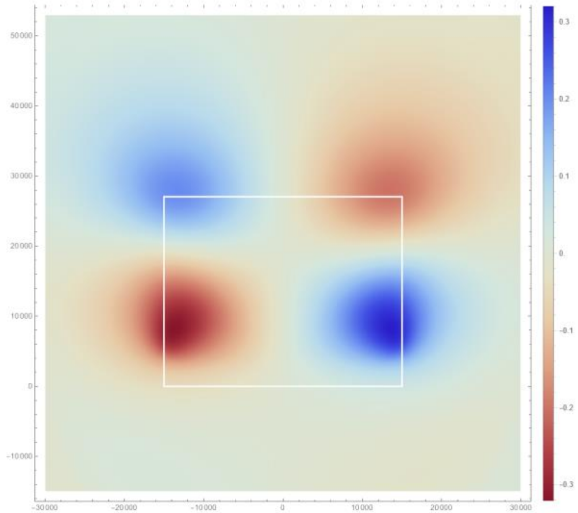
TPV37 Surface Deformation – Horizontal Component (Parallel to the Fault Trace)



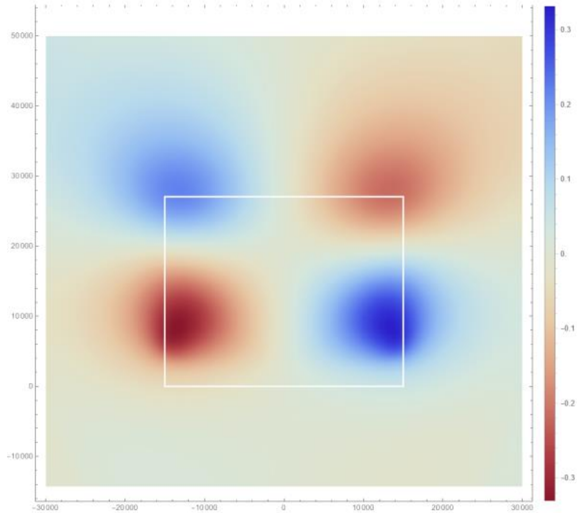
barall (FaultMod)



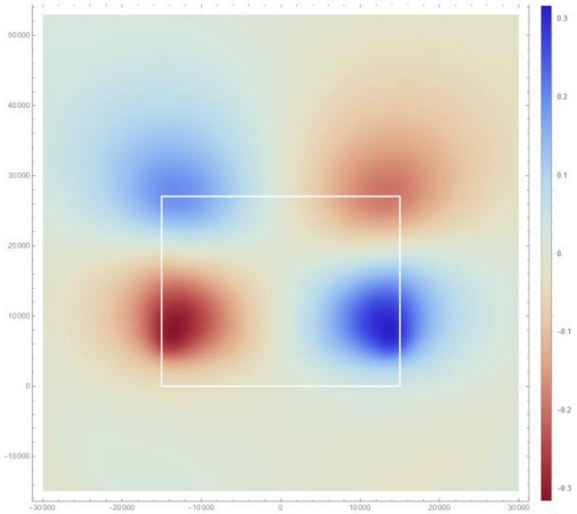
dliu (EQDyna)



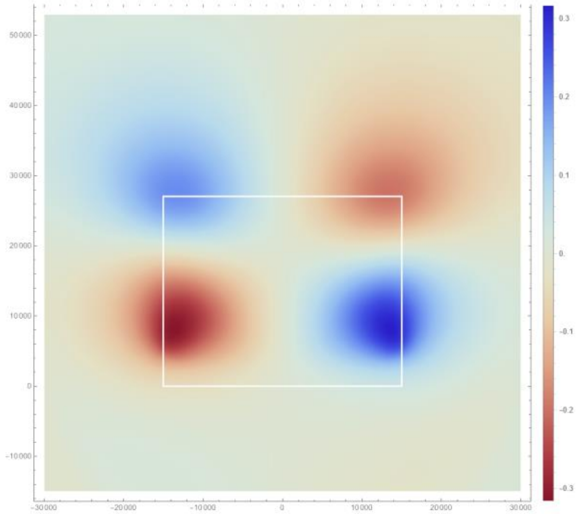
kutschera.2 (SeisSol)



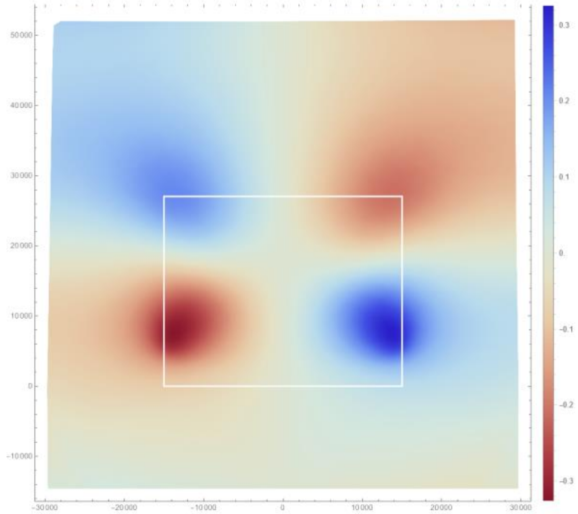
li (SeisSol)



ma (MAFE)



wzhang (Mixed-Flux DG)



yang (PyLith)

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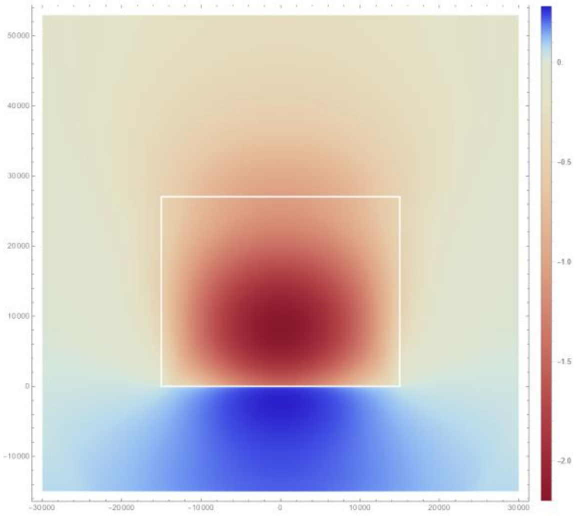
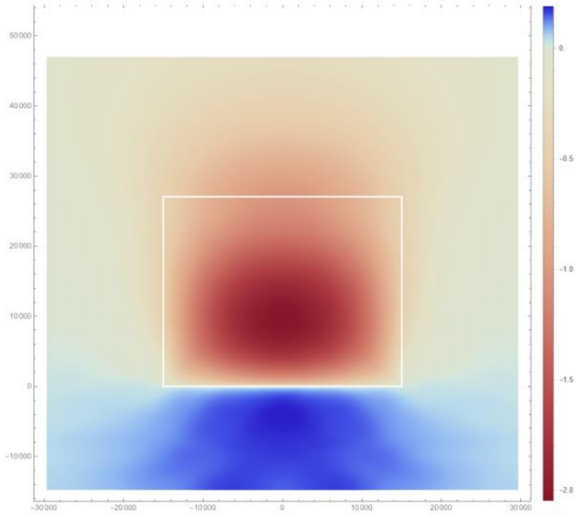
Red is displacement to the left.

Blue is displacement to the right

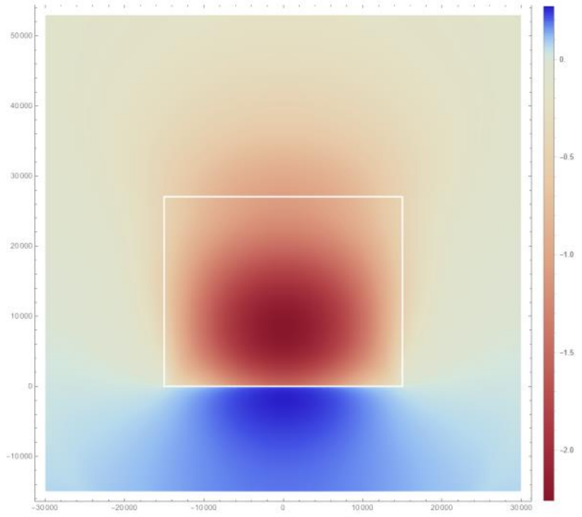
TPV36 Surface Deformation – Normal Component (Perpendicular to the Fault Trace)



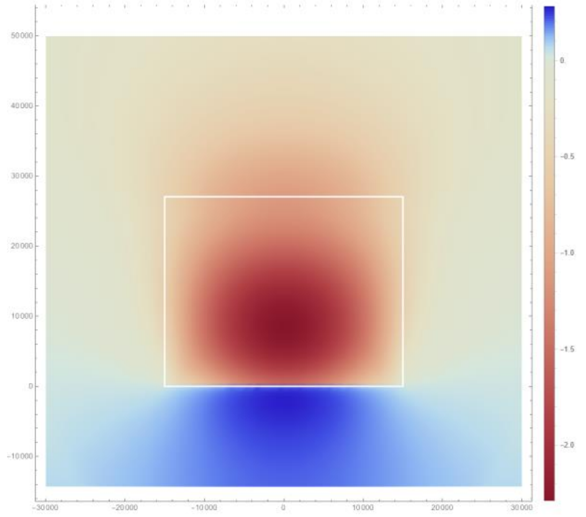
barall (FaultMod)



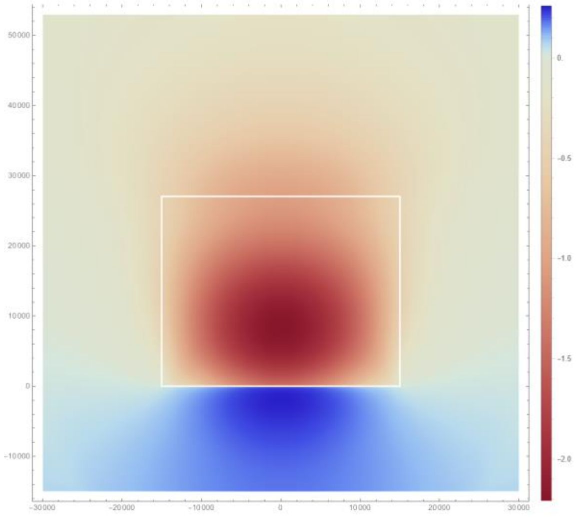
dliu.2 (EQDyna)



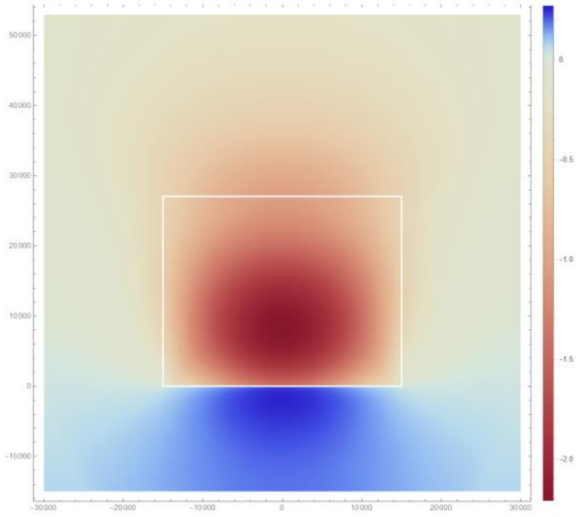
kutschera.2 (SeisSol)



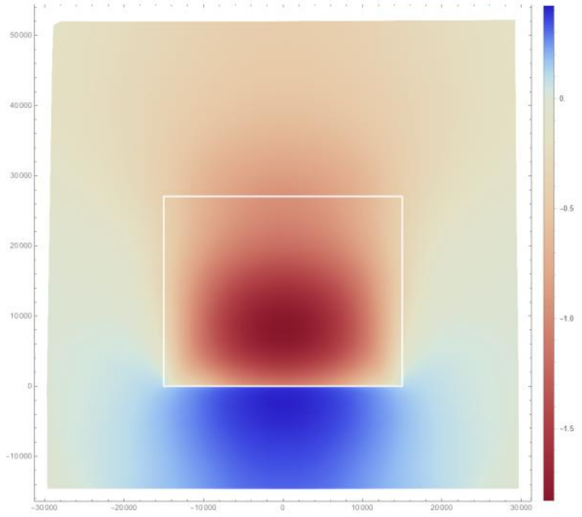
li.2 (SeisSol)



ma (MAFE)



wzhang (Mixed-Flux DG)



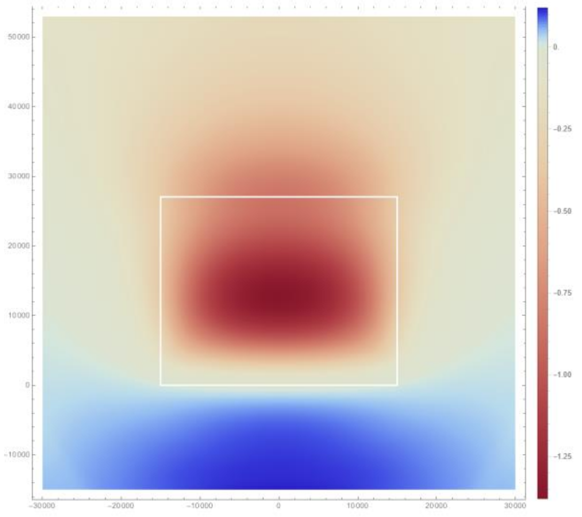
yang (PyLith)

White rectangle is the fault. Bottom edge of the rectangle is the fault trace.

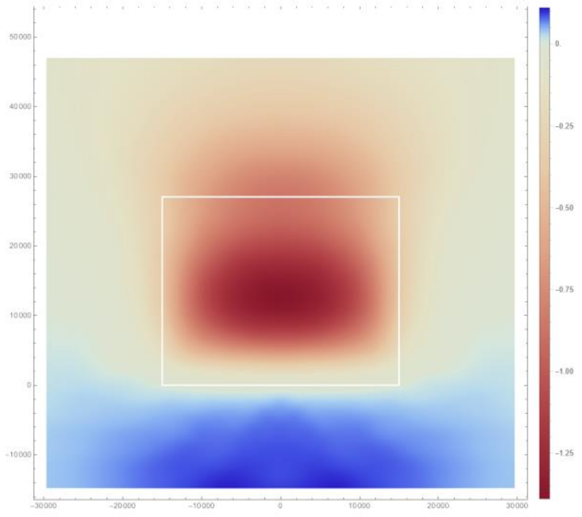
Red is displacement toward the bottom (the footwall).

Blue is displacement toward the top (the hanging wall)

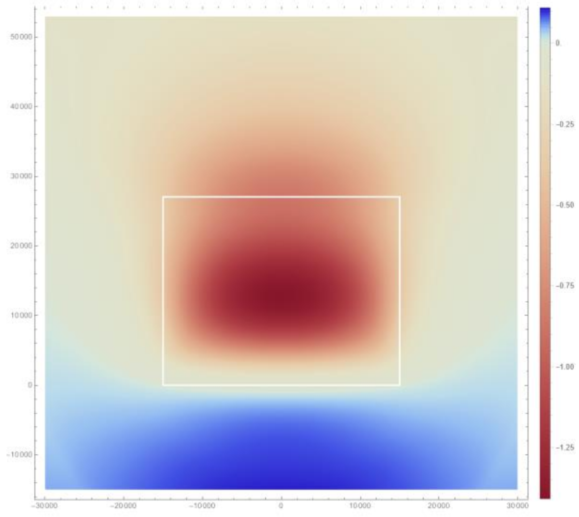
TPV37 Surface Deformation – Normal Component (Perpendicular to the Fault Trace)



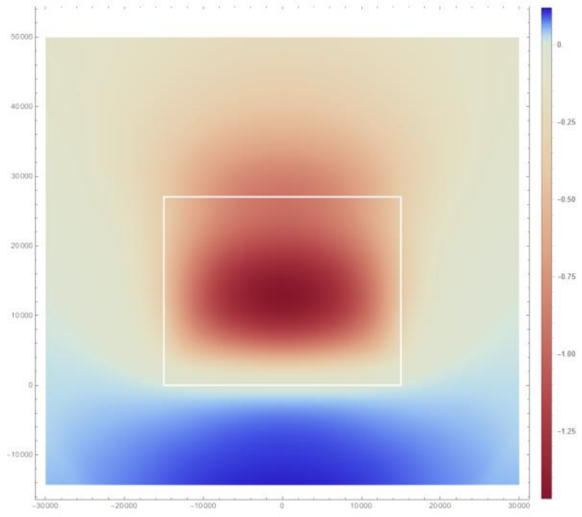
barall (FaultMod)



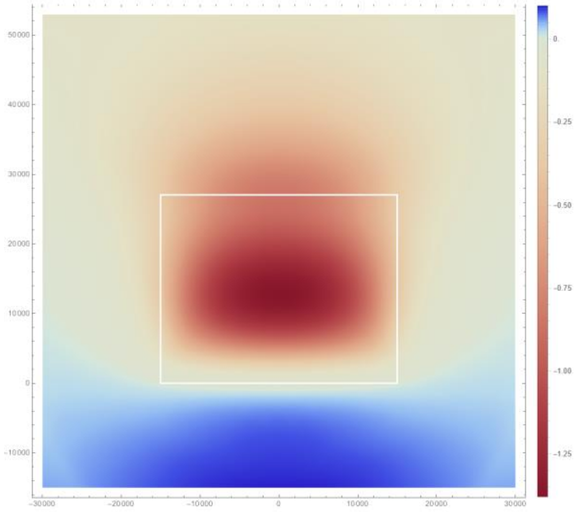
dliu (EQDyna)



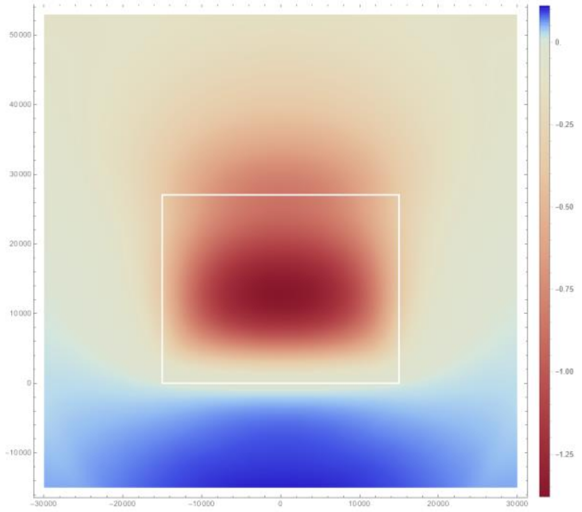
kutschera.2 (SeisSol)



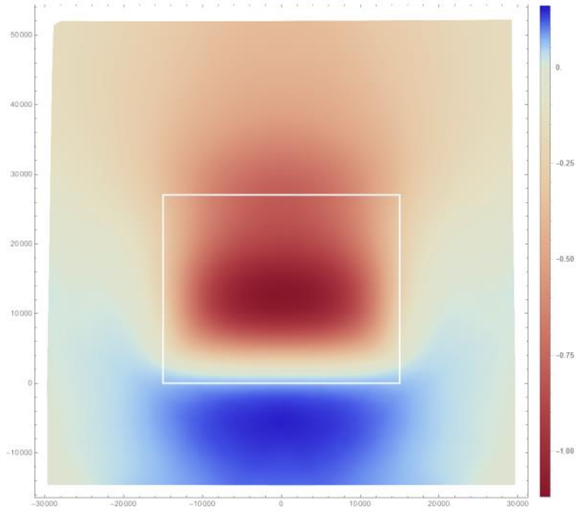
li (SeisSol)



ma (MAFE)



wzhang (Mixed-Flux DG)



yang (PyLith)

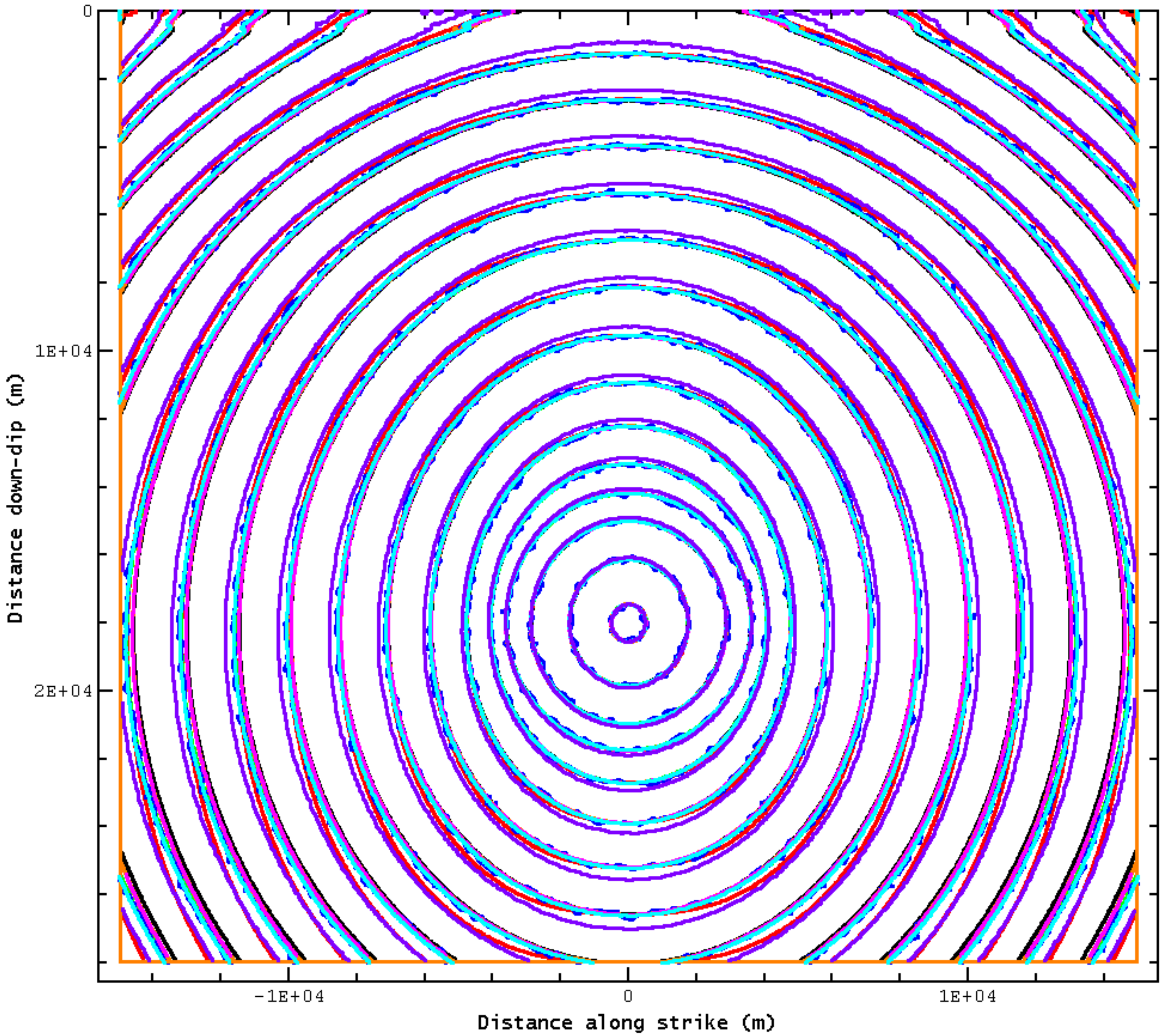
White rectangle is the fault. Bottom edge of the rectangle is the fault trace.

Red is displacement toward the bottom (the footwall).

Blue is displacement toward the top (the hanging wall)

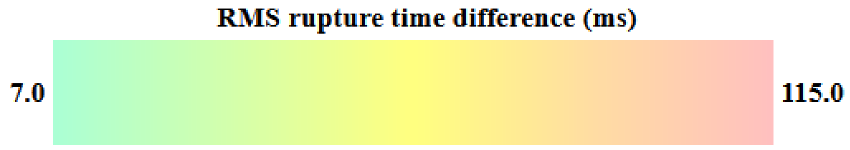
Rupture Contour Plots

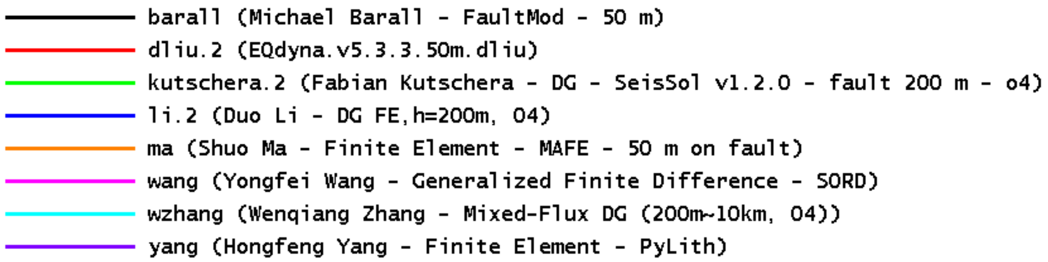
TPV36 Rupture Contour Plots and Matrics – For 8 Modelers



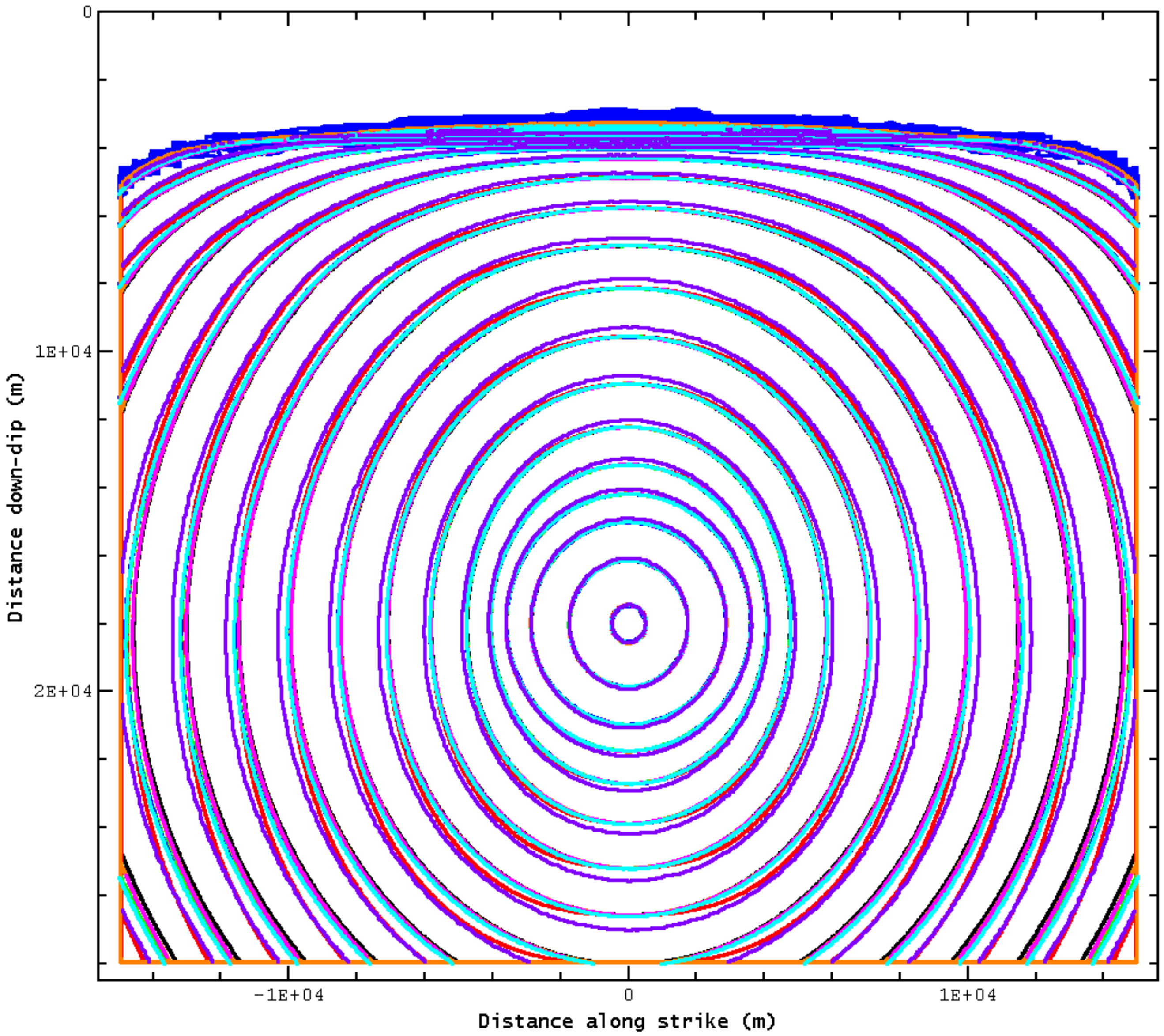
The metric value is the RMS difference in rupture time, in milliseconds, between each pair of codes.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
(1) barall		82.9	29.7	38.4	13.1	12.6	35.7	125.9
(2) dliu.2	82.9		58.5	58.1	71.0	70.0	53.4	61.1
(3) kutschera.2	29.7	58.5		19.4	19.7	19.4	7.0	100.2
(4) li.2	38.4	58.1	19.4		29.7	29.5	19.0	98.9
(5) ma	13.1	71.0	19.7	29.7		1.7	25.3	115.0
(6) wang	12.6	70.0	19.4	29.5	1.7		25.0	114.8
(7) wzhang	35.7	53.4	7.0	19.0	25.3	25.0		95.7
(8) yang	125.9	61.1	100.2	98.9	115.0	114.8	95.7	



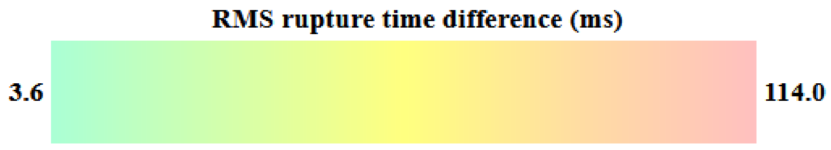


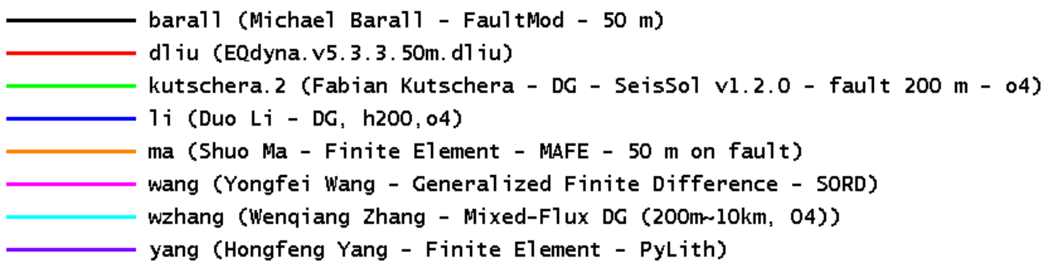
TPV37 Rupture Contour Plots and Matrics – For 8 Modelers



The metric value is the RMS difference in rupture time, in milliseconds, between each pair of codes.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
(1) barall		80.4	31.1	31.4	12.8	12.3	37.7	124.3
(2) dliu	80.4		54.5	39.1	68.7	67.7	48.9	60.9
(3) kutschera.2	31.1	54.5		5.8	21.2	20.9	7.5	98.2
(4) li	31.4	39.1	5.8		24.2	23.9	3.6	89.1
(5) ma	12.8	68.7	21.2	24.2		1.1	27.3	114.0
(6) wang	12.3	67.7	20.9	23.9	1.1		27.0	113.8
(7) wzhang	37.7	48.9	7.5	3.6	27.3	27.0		92.0
(8) yang	124.3	60.9	98.2	89.1	114.0	113.8	92.0	





Off-Fault Stations: Time Series Data

Metric Comparison for Each Pair of Users: Summary Across All Off-Fault Stations

TPV36

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
(1) barall		45.9	8.3	12.2	6.6	6.8	17.2	28.9
(2) dliu.2	45.9		46.2	46.3	44.8	44.8	49.4	55.2
(3) kutschera.2	8.3	46.2		8.7	6.1	7.1	18.3	30.2
(4) li.2	12.2	46.3	8.7		10.8	11.2	17.7	32.1
(5) ma	6.6	44.8	6.1	10.8		1.6	16.0	28.9
(6) wang	6.8	44.8	7.1	11.2	1.6		15.6	29.0
(7) wzhang	17.2	49.4	18.3	17.7	16.0	15.6		36.1
(8) yang	28.9	55.2	30.2	32.1	28.9	29.0	36.1	

Users	
(1) barall	Michael Barall - FaultMod - 50 m
(2) dliu.2	EQdyna.v5.3.3.50m.dliu
(3) kutschera.2	Fabian Kutschera - DG - SeisSol v1.2.0 - fault 200 m - o4
(4) li.2	Duo Li - DG FE,h=200m, O4
(5) ma	Shuo Ma - Finite Element - MAFE - 50 m on fault
(6) wang	Yongfei Wang - Generalized Finite Difference - SORD
(7) wzhang	Wenqiang Zhang - Mixed-Flux DG (200m~10km, O4)
(8) yang	Hongfeng Yang - Finite Element - PyLith

TPV37

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
(1) barall		47.0	6.9	10.0	5.3	6.0	9.5	36.2
(2) dliu	47.0		46.2	45.3	45.7	41.3	46.8	62.7
(3) kutschera.2	6.9	46.2		7.1	5.3	7.7	10.3	37.9
(4) li	10.0	45.3	7.1		9.3	11.1	14.2	35.6
(5) ma	5.3	45.7	5.3	9.3		4.1	8.4	37.0
(6) wang	6.0	41.3	7.7	11.1	4.1		7.1	37.0
(7) wzhang	9.5	46.8	10.3	14.2	8.4	7.1		38.8
(8) yang	36.2	62.7	37.9	35.6	37.0	37.0	38.8	

Users	
(1) barall	Michael Barall - FaultMod - 50 m
(2) dliu	EQdyna.v5.3.3.50m.dliu
(3) kutschera.2	Fabian Kutschera - DG - SeisSol v1.2.0 - fault 200 m - o4
(4) li	Duo Li - DG, h200,o4
(5) ma	Shuo Ma - Finite Element - MAFE - 50 m on fault
(6) wang	Yongfei Wang - Generalized Finite Difference - SORD
(7) wzhang	Wenqiang Zhang - Mixed-Flux DG (200m~10km, O4)
(8) yang	Hongfeng Yang - Finite Element - PyLith

The metric for two time series is the RMS difference between them, normalized to the range 0 to 200.

- Lower numbers are better; 0 is a perfect match, and values about 10 or less are a good match.
- We apply an optimum relative time shift when comparing, allowing for differences in propagation speed.

Metric Comparison for Each Off-Fault Station: Summary Across All Users

TPV36

	3d-disp	3d-vel	t-shift
body-010st000dp000	67.9	60.6	0.211
body-010st100dp000	32.1	26.5	0.057
body-030st000dp000	24.6	34.2	0.045
body-090st000dp000	24.5	39.2	0.062
body-090st100dp000	30.8	52.7	0.233
body-090st200dp000	35.1	56.5	0.286
body010st000dp000	15.6	23.8	0.040
body010st100dp000	10.8	16.2	0.062
body030st000dp000	8.3	18.2	0.036
body090st000dp000	5.5	16.2	0.126
body090st100dp000	4.8	10.6	0.058
body090st200dp000	11.4	26.8	0.087
body150st000dp000	7.2	18.3	0.143
body210st000dp000	8.0	20.0	0.086
body270st000dp000	5.8	20.4	0.065
body270st100dp000	5.4	22.1	0.089
body270st200dp000	9.5	29.5	0.087
body330st000dp000	6.7	22.4	0.079
body390st000dp000	51.9	52.3	0.175
body450st000dp000	10.7	24.3	0.128
body450st100dp000	12.1	30.7	0.115
body450st200dp000	13.6	30.8	0.090

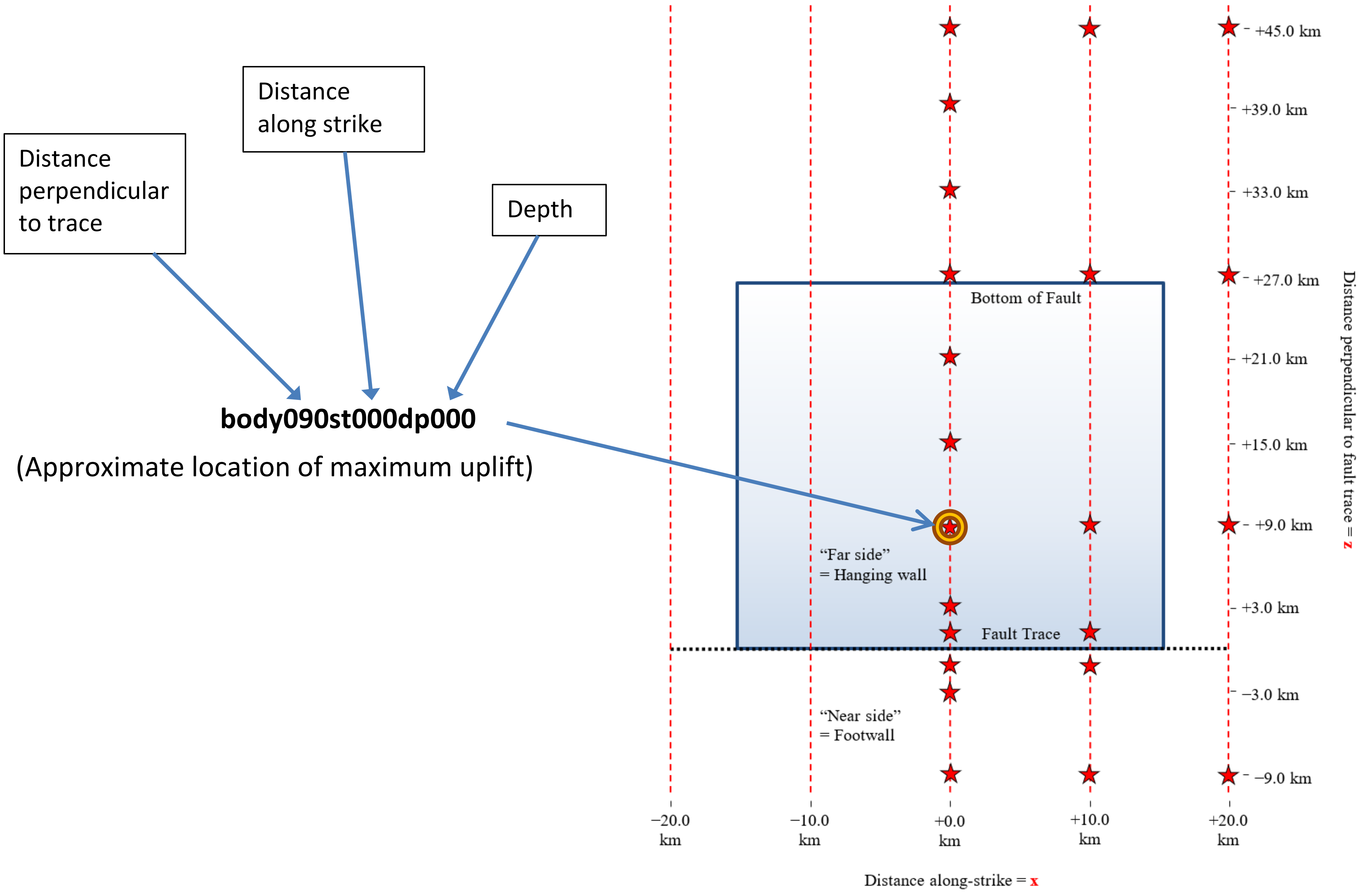
Footwall

TPV37

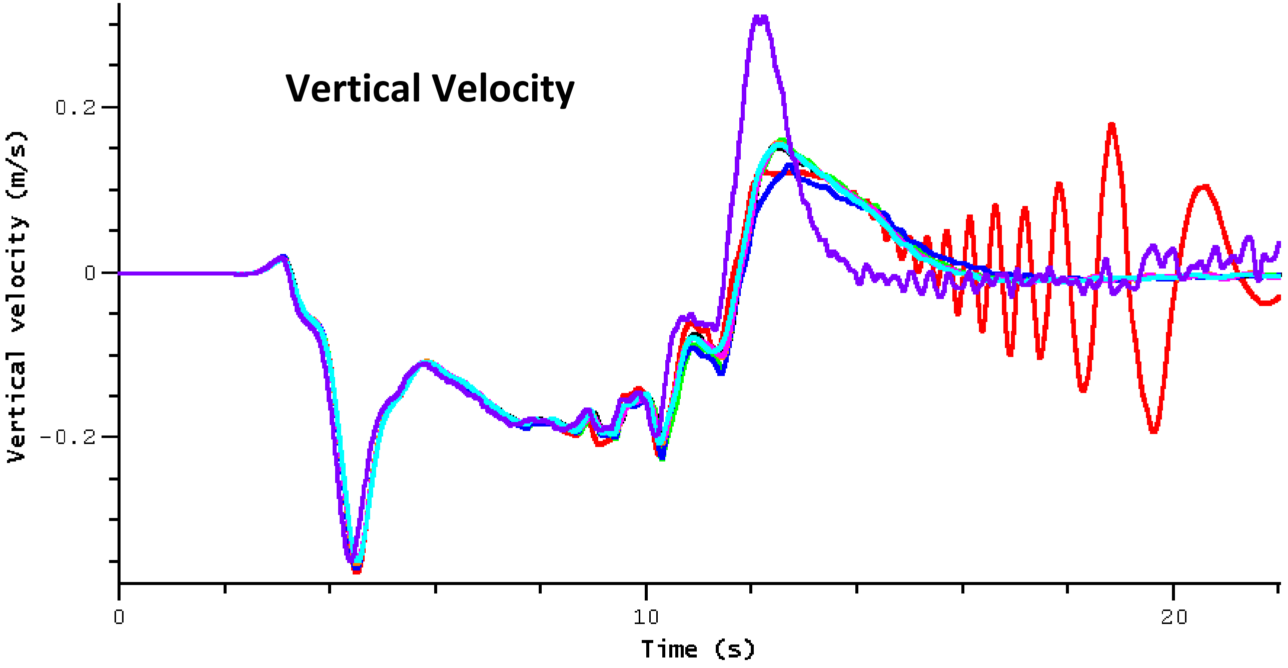
	3d-disp	3d-vel	t-shift
body-010st000dp000	36.0	38.2	0.045
body-010st100dp000	34.7	31.9	0.048
body-030st000dp000	33.4	37.7	0.047
body-090st000dp000	29.0	40.3	0.068
body-090st100dp000	28.9	41.2	0.077
body-090st200dp000	37.5	41.3	0.259
body010st000dp000	26.0	33.7	0.041
body010st100dp000	25.2	28.9	0.052
body030st000dp000	11.7	24.7	0.036
body090st000dp000	5.2	13.9	0.073
body090st100dp000	4.5	9.6	0.048
body090st200dp000	11.7	27.2	0.085
body150st000dp000	7.2	17.3	0.102
body210st000dp000	8.8	21.0	0.084
body270st000dp000	5.7	20.7	0.066
body270st100dp000	5.4	22.6	0.087
body270st200dp000	10.7	30.7	0.086
body330st000dp000	7.7	24.7	0.088
body390st000dp000	58.8	57.3	0.236
body450st000dp000	13.4	27.9	0.142
body450st100dp000	15.1	34.9	0.124
body450st200dp000	17.4	33.9	0.099

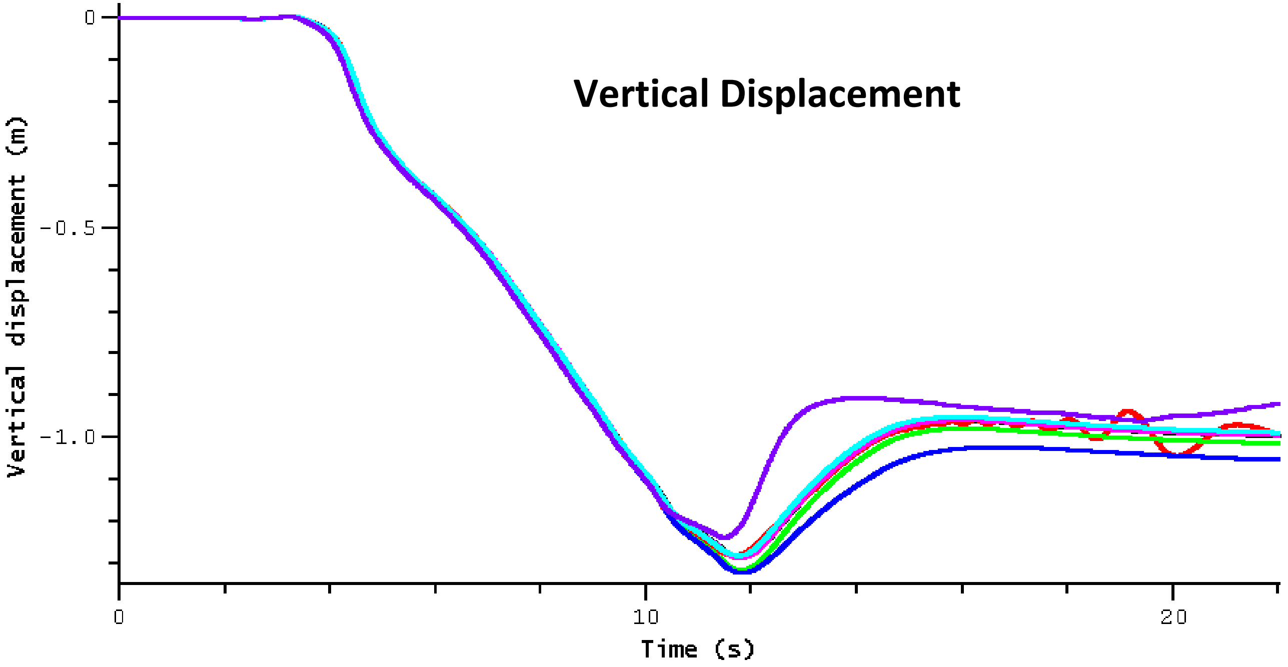
Fields	
3d-disp	Displacement vector
3d-vel	Velocity vector
t-shift	Time shift

Off-Fault Stations	
body-010st000dp000	body -1.0 km, strike 0.0 km, depth 0.0 km
body-010st100dp000	body -1.0 km, strike 10.0 km, depth 0.0 km
body-030st000dp000	body -3.0 km, strike 0.0 km, depth 0.0 km
body-090st000dp000	body -9.0 km, strike 0.0 km, depth 0.0 km
body-090st100dp000	body -9.0 km, strike 10.0 km, depth 0.0 km
body-090st200dp000	body -9.0 km, strike 20.0 km, depth 0.0 km
body010st000dp000	body 1.0 km, strike 0.0 km, depth 0.0 km
body010st100dp000	body 1.0 km, strike 10.0 km, depth 0.0 km
body030st000dp000	body 3.0 km, strike 0.0 km, depth 0.0 km
body090st000dp000	body 9.0 km, strike 0.0 km, depth 0.0 km
body090st100dp000	body 9.0 km, strike 10.0 km, depth 0.0 km
body090st200dp000	body 9.0 km, strike 20.0 km, depth 0.0 km
body150st000dp000	body 15.0 km, strike 0.0 km, depth 0.0 km
body210st000dp000	body 21.0 km, strike 0.0 km, depth 0.0 km
body270st000dp000	body 27.0 km, strike 0.0 km, depth 0.0 km
body270st100dp000	body 27.0 km, strike 10.0 km, depth 0.0 km
body270st200dp000	body 27.0 km, strike 20.0 km, depth 0.0 km
body330st000dp000	body 33.0 km, strike 0.0 km, depth 0.0 km
body390st000dp000	body 39.0 km, strike 0.0 km, depth 0.0 km
body450st000dp000	body 45.0 km, strike 0.0 km, depth 0.0 km
body450st100dp000	body 45.0 km, strike 10.0 km, depth 0.0 km
body450st200dp000	body 45.0 km, strike 20.0 km, depth 0.0 km


Distance perpendicular to trace
Distance along strike
Depth
body090st000dp000
(Approximate location of maximum uplift)
+45.0 km
+39.0 km
+33.0 km
+27.0 km
Bottom of Fault
+21.0 km
+15.0 km
+9.0 km
"Far side"
= Hanging wall
+3.0 km
Fault Trace
−3.0 km
"Near side"
= Footwall
−9.0 km
−20.0 km
−10.0 km
+0.0 km
+10.0 km
+20.0 km
Distance along-strike = x
Distance perpendicular to fault trace = z

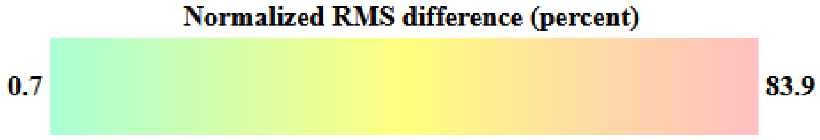
TPV36 – Off-Fault Station: body090st000dp000

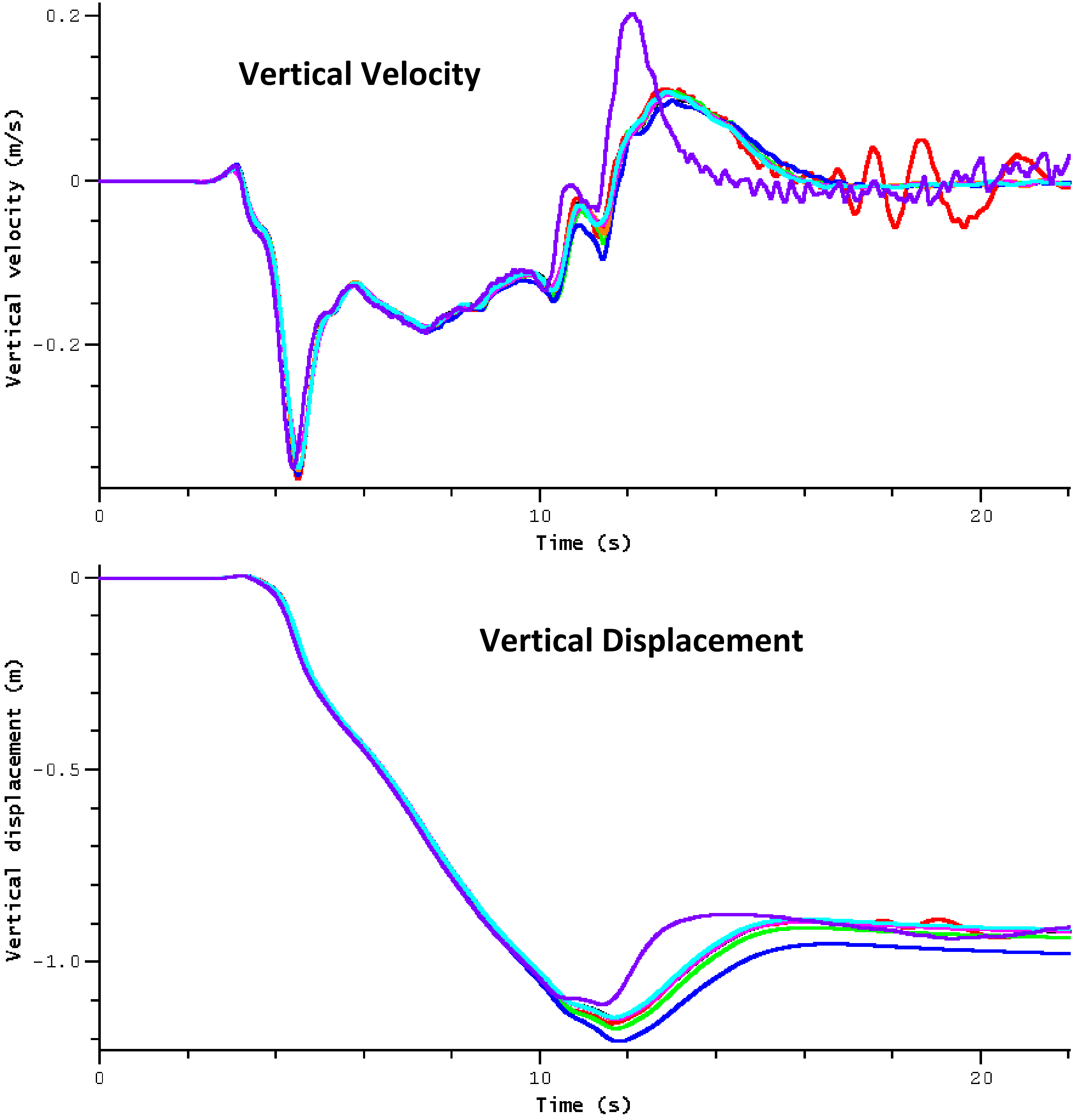




Metrics for velocity

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
(1) barall		28.7	4.0	9.3	2.0	2.0	3.4	27.8
(2) dliu.2	28.7		29.3	31.0	28.7	28.7	28.1	34.7
(3) kutschera.2	4.0	29.3		8.2	3.4	3.6	4.5	28.9
(4) li.2	9.3	31.0	8.2		9.2	9.0	9.9	32.8
(5) ma	2.0	28.7	3.4	9.2		0.5	2.9	27.5
(6) wang	2.0	28.7	3.6	9.0	0.5		2.8	27.4
(7) wzhang	3.4	28.1	4.5	9.9	2.9	2.8		26.1
(8) yang	27.8	34.7	28.9	32.8	27.5	27.4	26.1	





TPV37 – Off-Fault Station: body090st000dp000

Metrics for velocity

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
(1) barall		16.4	3.7	10.2	2.0	3.3	3.2	27.8
(2) dliu	16.4		16.5	19.4	16.3	16.7	16.1	31.3
(3) kutschera.2	3.7	16.5		8.8	3.6	4.6	4.6	28.9
(4) li	10.2	19.4	8.8		10.2	10.4	11.3	33.7
(5) ma	2.0	16.3	3.6	10.2		2.8	3.0	27.6
(6) wang	3.3	16.7	4.6	10.4	2.8		3.2	27.6
(7) wzhang	3.2	16.1	4.6	11.3	3.0	3.2		26.5
(8) yang	27.8	31.3	28.9	33.7	27.6	27.6	26.5	

Normalized RMS difference (percent)

barall (Michael Barall - FaultMod - 50 m)
dliu (EQdyna.v5.3.3.50m.dliu)
kutschera.2 (Fabian Kutschera - DG - SeisSol v1.2.0 - fault 200 m - o4)
li (Duo Li - DG, h200,o4)
ma (Shuo Ma - Finite Element - MAFE - 50 m on fault)
wang (Yongfei Wang - Generalized Finite Difference - SORD)
wzhang (Wenqiang Zhang - Mixed-Flux DG (200m~10km, O4))
yang (Hongfeng Yang - Finite Element - PyLith)

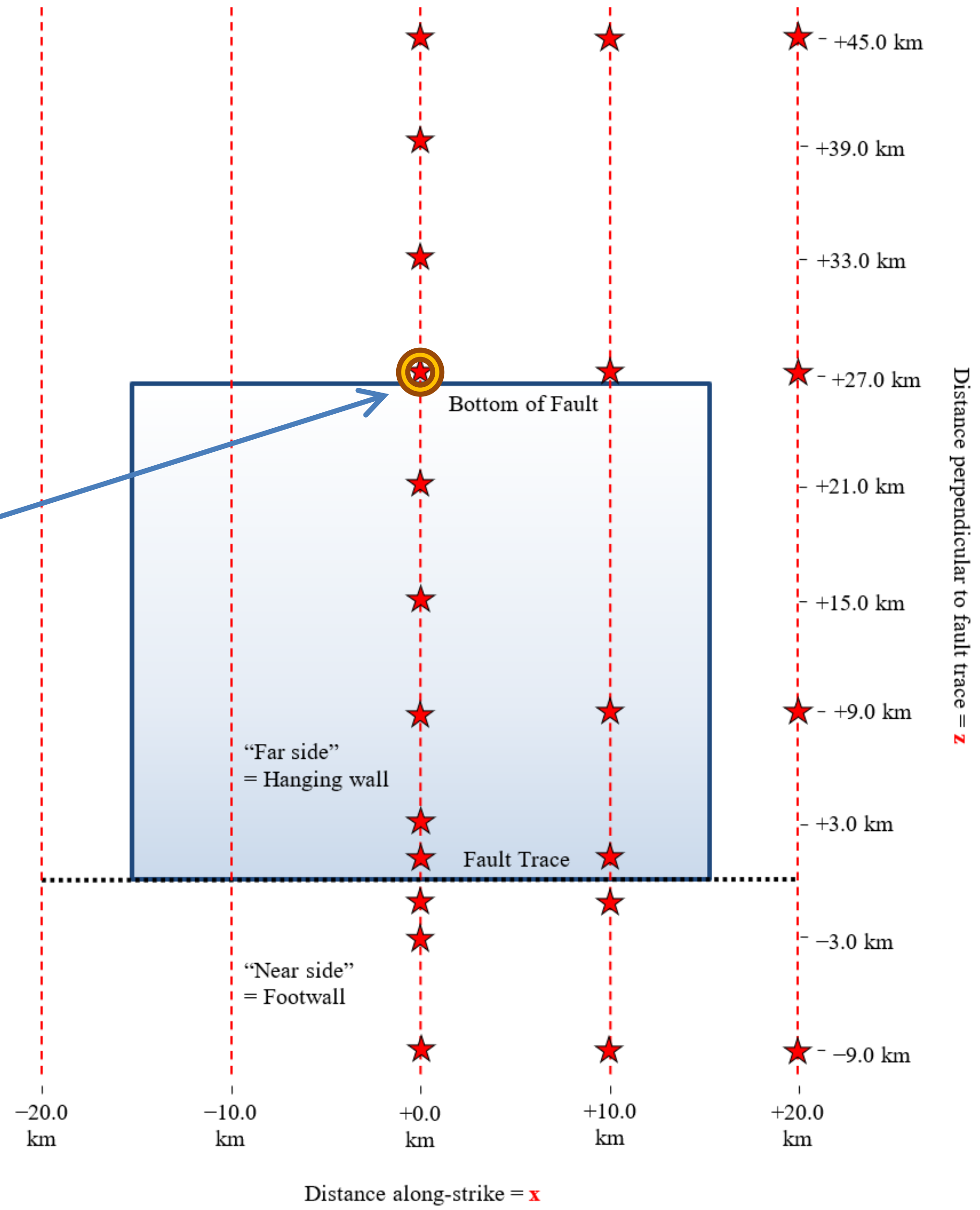
Distance perpendicular to trace

Distance along strike

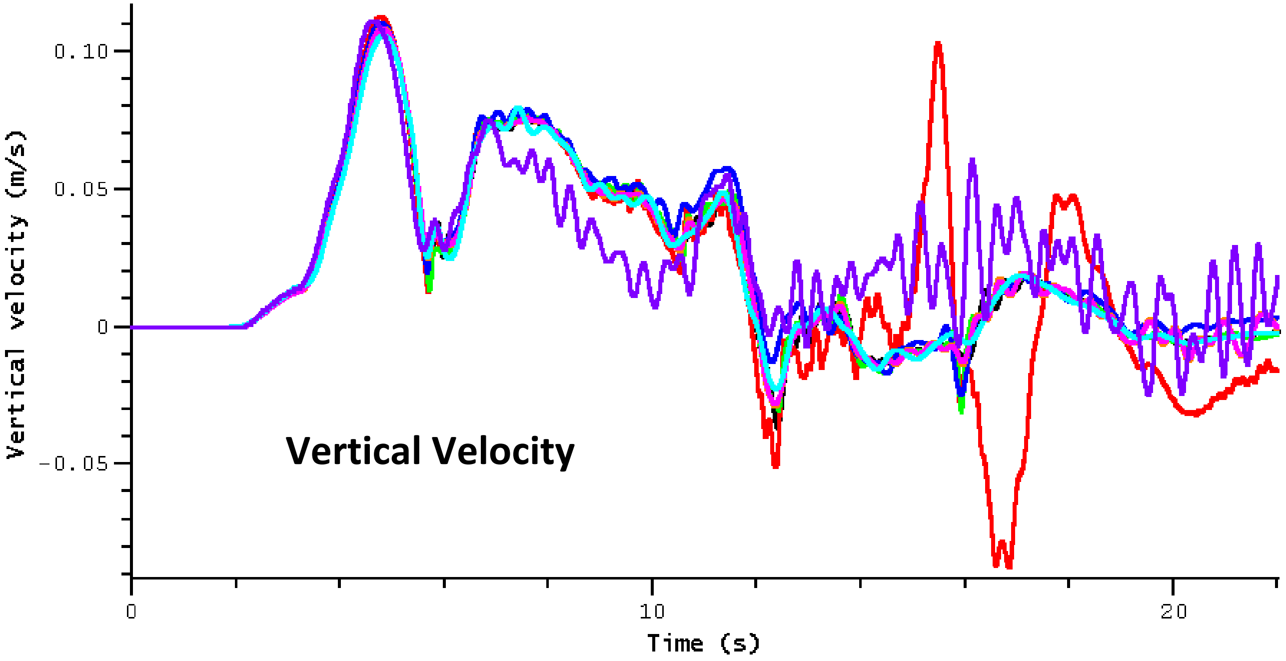
Depth

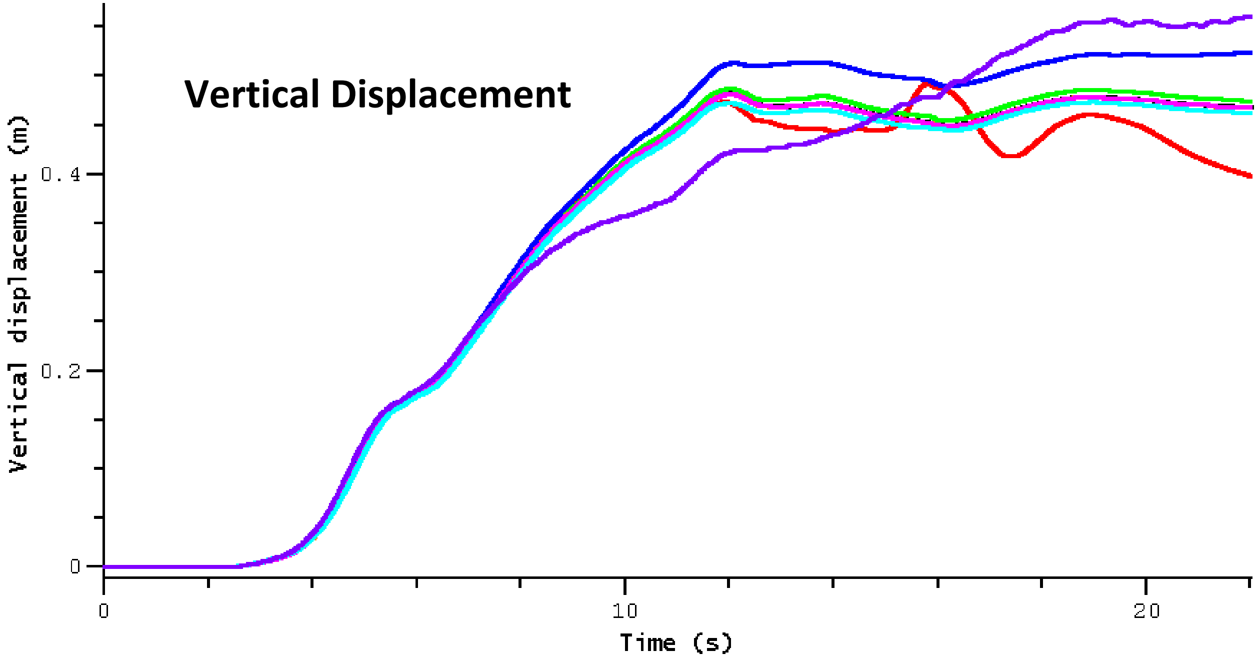
body270st000dp000

(Approximate location of maximum subsidence)



TPV36 – Off-Fault Station: body270st000dp000





Metrics for velocity

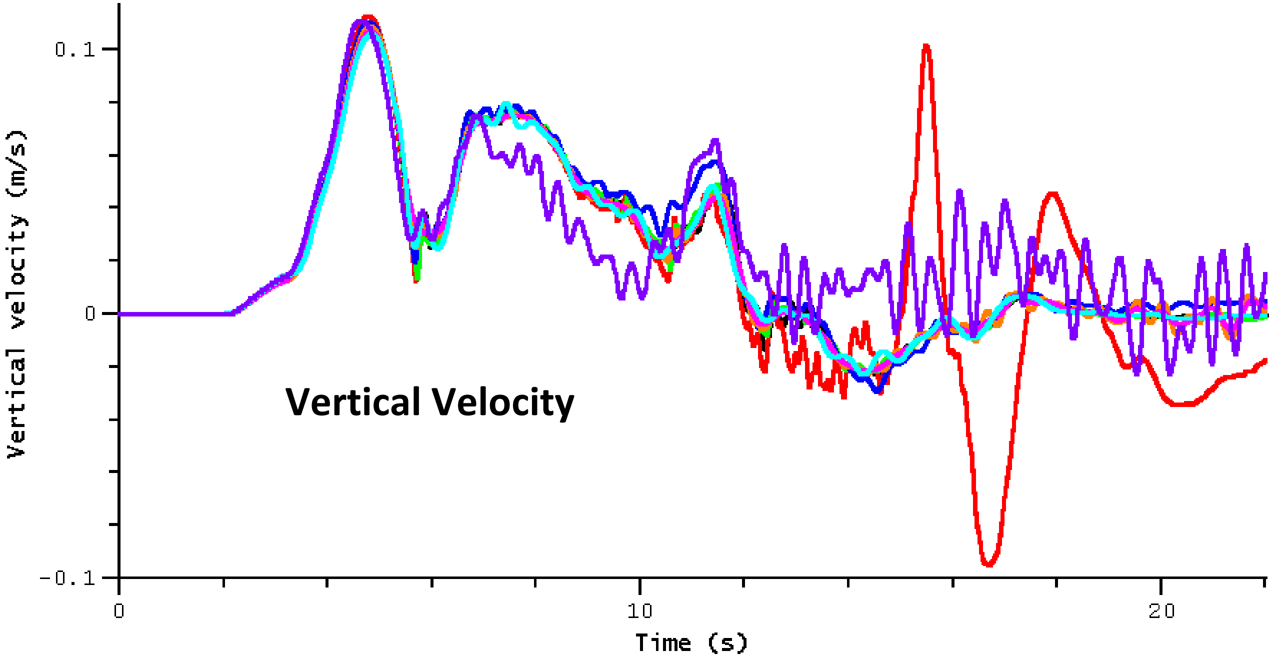
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
(1) barall		29.7	11.3	17.2	8.8	8.2	11.2	32.0
(2) dliu.2	29.7		26.9	30.3	28.0	28.2	29.6	44.1
(3) kutschera.2	11.3	26.9		11.8	7.0	7.1	10.2	33.5
(4) li.2	17.2	30.3	11.8		14.1	14.0	15.0	36.8
(5) ma	8.8	28.0	7.0	14.1		1.7	9.4	32.2
(6) wang	8.2	28.2	7.1	14.0	1.7		8.3	31.9
(7) wzhang	11.2	29.6	10.2	15.0	9.4	8.3		31.3
(8) yang	32.0	44.1	33.5	36.8	32.2	31.9	31.3	

Normalized RMS difference (percent)

0.7 — 83.9

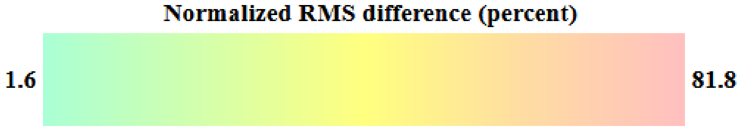
- barall (Michael Barall - FaultMod - 50 m)
- dliu.2 (EQdyna.v5.3.3.50m.dliu)
- kutschera.2 (Fabian Kutschera - DG - SeisSol v1.2.0 - fault 200 m - o4)
- li.2 (Duo Li - DG FE,h=200m, O4)
- ma (Shuo Ma - Finite Element - MAFE - 50 m on fault)
- wang (Yongfei Wang - Generalized Finite Difference - SORD)
- wzhang (Wenqiang Zhang - Mixed-Flux DG (200m~10km, O4))
- yang (Hongfeng Yang - Finite Element - PyLith)

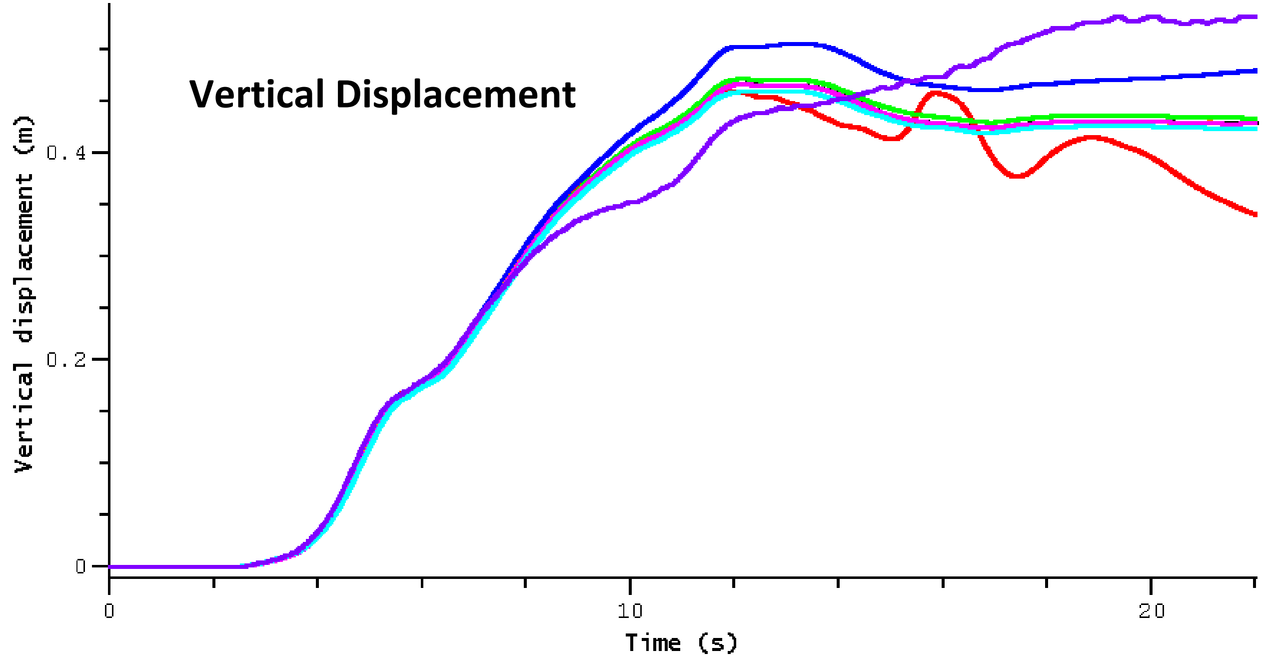
TPV37 – Off-Fault Station: body270st000dp000



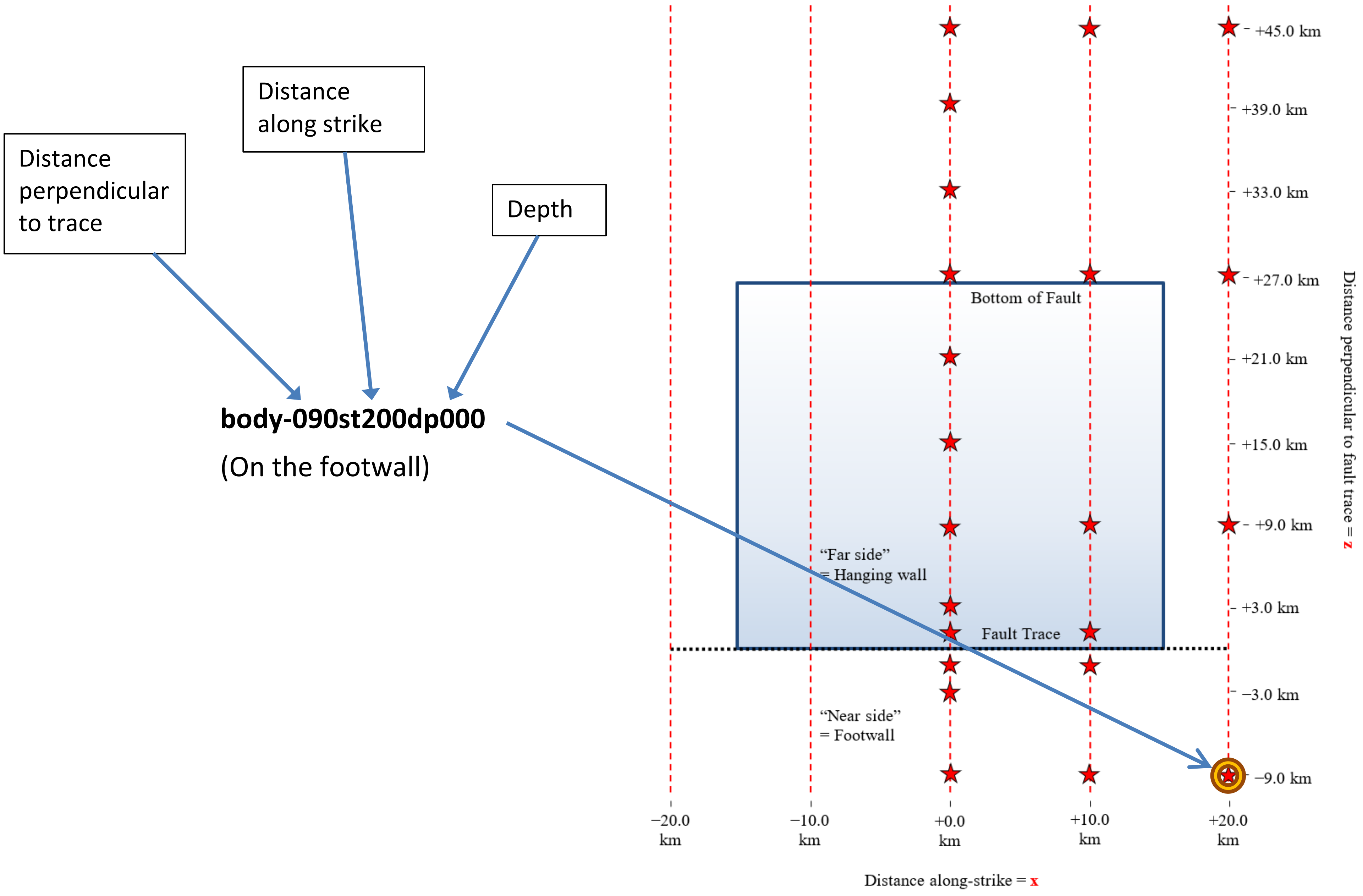
Metrics for velocity

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
(1) barall		31.0	11.3	17.4	9.2	9.5	11.9	30.5
(2) dliu	31.0		27.8	30.6	29.1	30.9	30.8	43.9
(3) kutschera.2	11.3	27.8		12.3	7.0	9.8	10.5	31.6
(4) li	17.4	30.6	12.3		14.1	15.1	14.8	35.8
(5) ma	9.2	29.1	7.0	14.1		7.5	9.9	30.6
(6) wang	9.5	30.9	9.8	15.1	7.5		6.5	29.5
(7) wzhang	11.9	30.8	10.5	14.8	9.9	6.5		29.5
(8) yang	30.5	43.9	31.6	35.8	30.6	29.5	29.5	

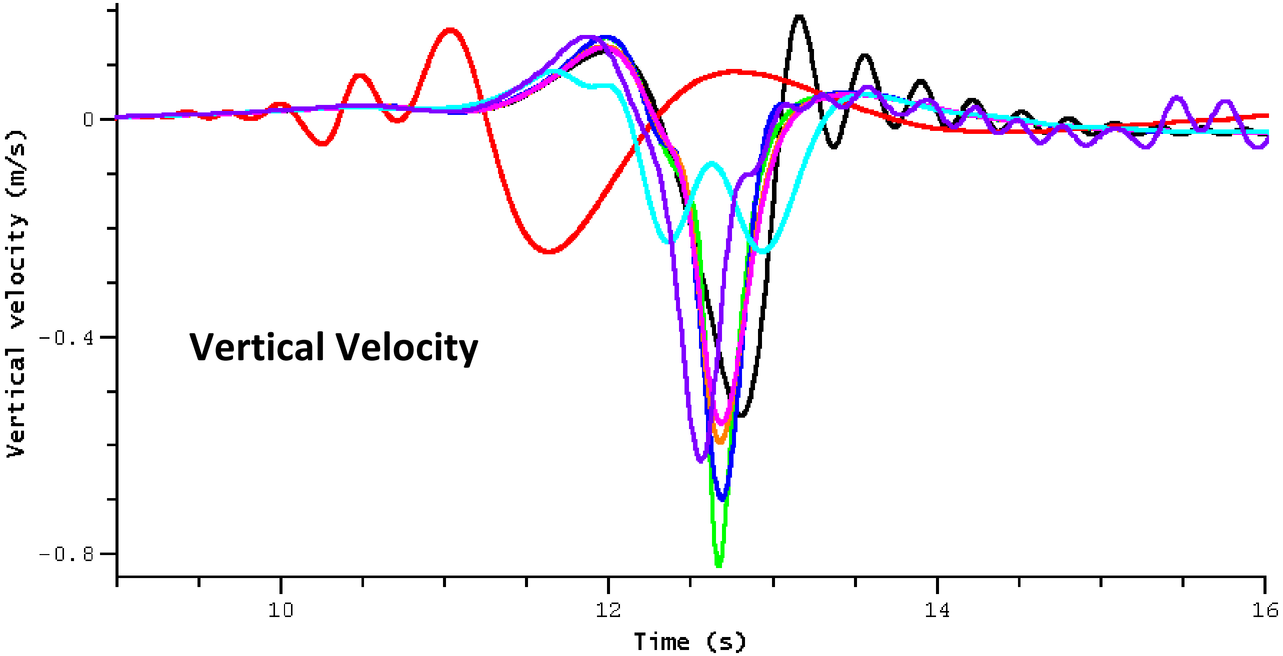


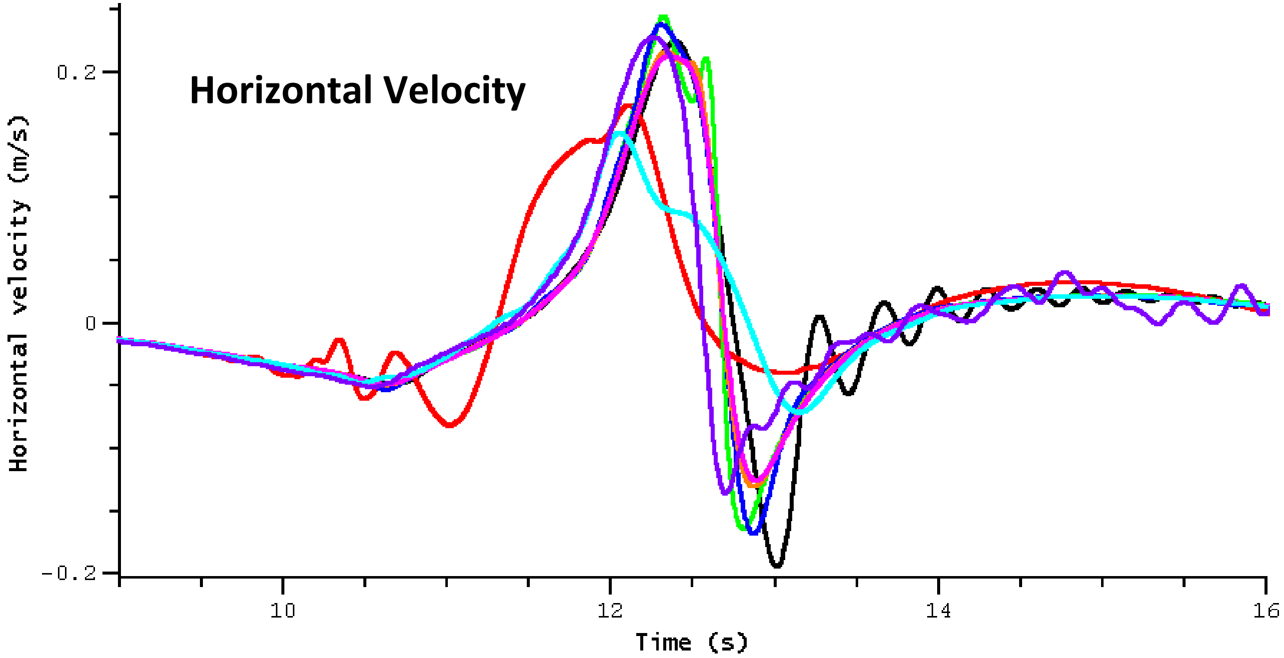


barall (Michael Barall - FaultMod - 50 m)
dliu (EQdyna.v5.3.3.50m.dliu)
kutschera.2 (Fabian Kutschera - DG - SeisSol v1.2.0 - fault 200 m - o4)
li (Duo Li - DG, h200,o4)
ma (Shuo Ma - Finite Element - MAFE - 50 m on fault)
wang (Yongfei Wang - Generalized Finite Difference - SORD)
wzhang (Wenqiang Zhang - Mixed-Flux DG (200m~10km, O4))
yang (Hongfeng Yang - Finite Element - PyLith)


Distance perpendicular to trace
Distance along strike
Depth
body-090st200dp000
(On the footwall)
+45.0 km
+39.0 km
+33.0 km
+27.0 km
Bottom of Fault
+21.0 km
+15.0 km
+9.0 km
“Far side”
= Hanging wall
+3.0 km
Fault Trace
−3.0 km
“Near side”
= Footwall
−9.0 km
−20.0 km
−10.0 km
+0.0 km
+10.0 km
+20.0 km
Distance along-strike = x
Distance perpendicular to fault trace = z

TPV36 – Off-Fault Station: body-090st200dp000





Metrics for velocity

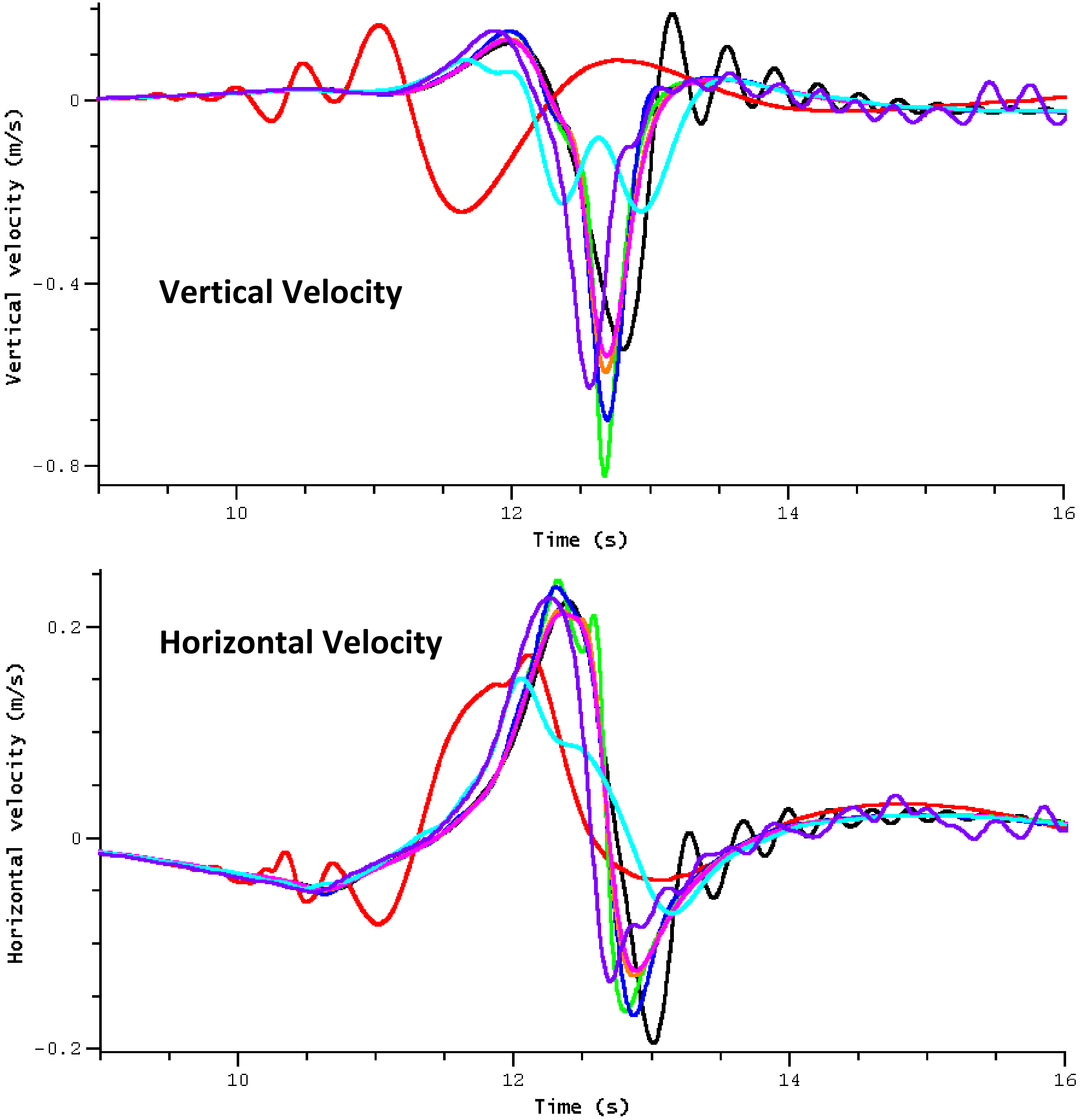
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
(1) barall		97.8	38.0	30.0	31.8	31.1	86.6	41.6
(2) dliu.2	97.8		99.1	97.8	94.1	92.9	96.2	95.2
(3) kutschera.2	38.0	99.1		14.7	20.1	24.1	94.0	30.5
(4) li.2	30.0	97.8	14.7		14.9	18.2	92.3	27.1
(5) ma	31.8	94.1	20.1	14.9		4.8	85.5	25.0
(6) wang	31.1	92.9	24.1	18.2	4.8		83.4	25.6
(7) wzhang	86.6	96.2	94.0	92.3	85.5	83.4		91.0
(8) yang	41.6	95.2	30.5	27.1	25.0	25.6	91.0	

Normalized RMS difference (percent)

0.7 — 83.9

- barall (Michael Barall - FaultMod - 50 m)
- dliu.2 (EQdyna.v5.3.3.50m.dliu)
- kutschera.2 (Fabian Kutschera - DG - SeisSol v1.2.0 - fault 200 m - o4)
- li.2 (Duo Li - DG FE,h=200m, O4)
- ma (Shuo Ma - Finite Element - MAFE - 50 m on fault)
- wang (Yongfei Wang - Generalized Finite Difference - SORD)
- wzhang (Wenqiang Zhang - Mixed-Flux DG (200m~10km, O4))
- yang (Hongfeng Yang - Finite Element - PyLith)

TPV36 – Off-Fault Station: body-090st200dp000



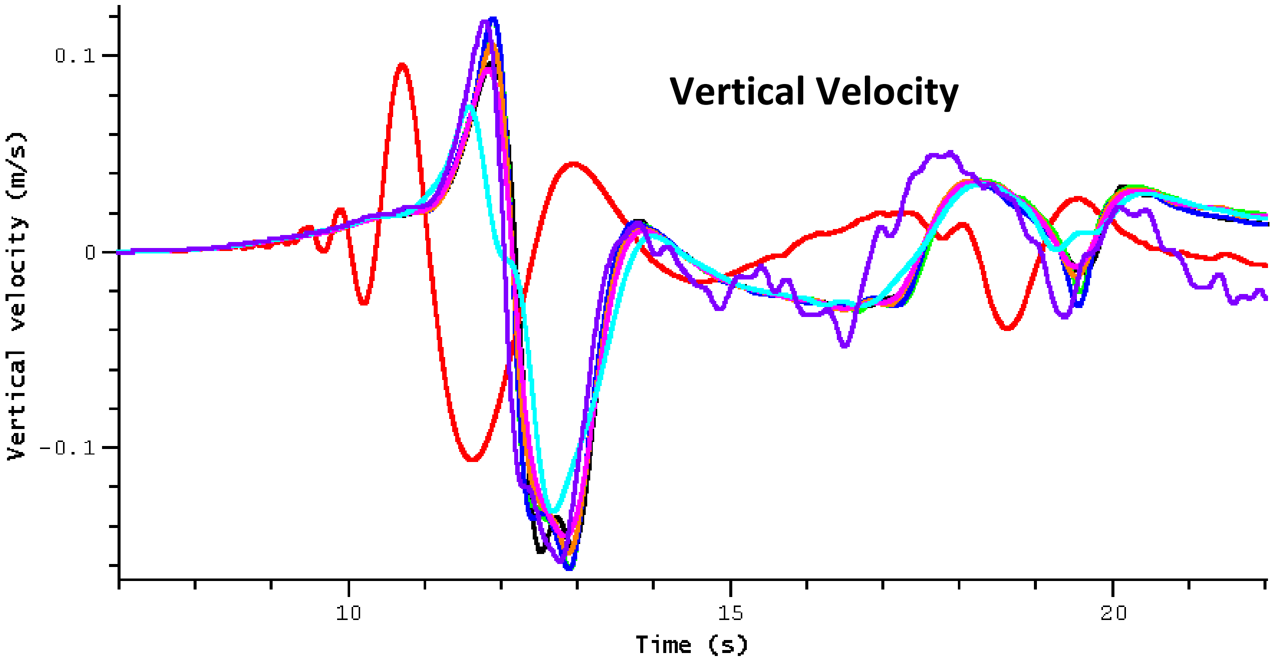
Metrics for time shift

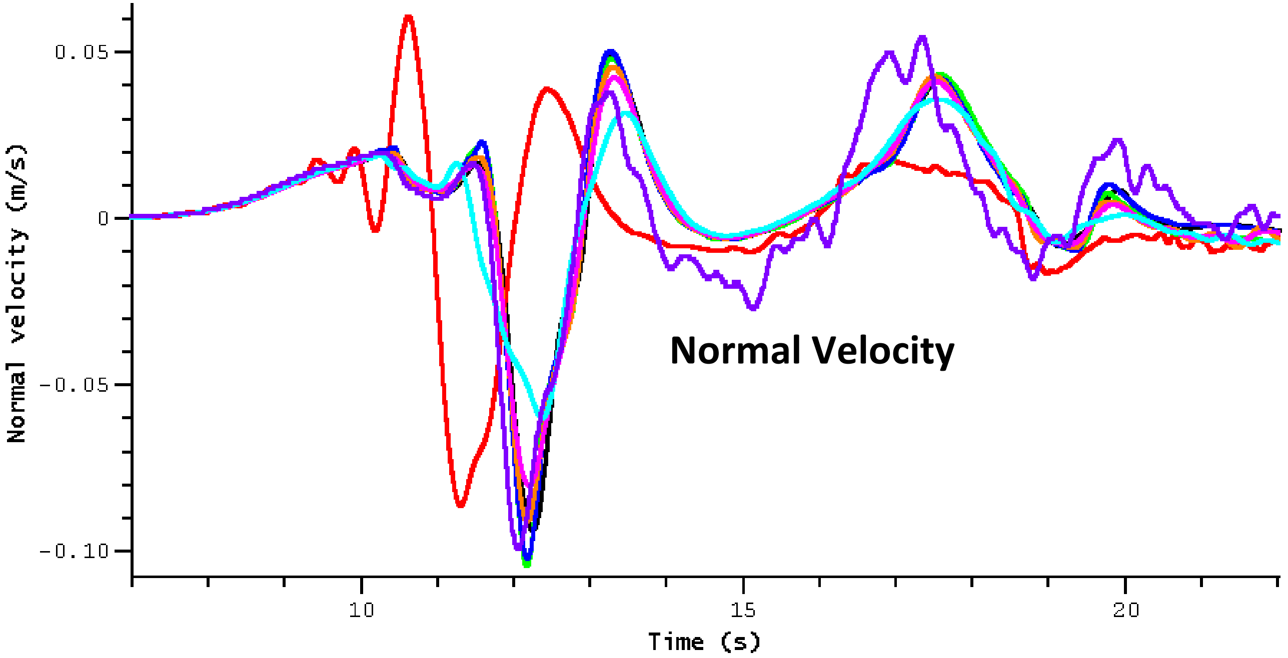
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
(1) barall		0.932	0.080	0.080	0.060	0.056	-0.102	0.196
(2) dliu.2	-0.932		-0.904	-0.900	-0.910	-0.910	-0.778	-0.788
(3) kutschera.2	-0.080	0.904		0.000	-0.004	-0.008	-0.174	0.126
(4) li.2	-0.080	0.900	-0.000		-0.008	-0.012	-0.178	0.126
(5) ma	-0.060	0.910	0.004	0.008		-0.002	-0.152	0.132
(6) wang	-0.056	0.910	0.008	0.012	0.002		-0.142	0.134
(7) wzhang	0.102	0.778	0.174	0.178	0.152	0.142		-0.108
(8) yang	-0.196	0.788	-0.126	-0.126	-0.132	-0.134	0.108	

Time shift (s)

barall (Michael Barall - FaultMod - 50 m)
dliu.2 (EQdyna.v5.3.3.50m.dliu)
kutschera.2 (Fabian Kutschera - DG - SeisSol v1.2.0 - fault 200 m - o4)
li.2 (Duo Li - DG FE,h=200m, O4)
ma (Shuo Ma - Finite Element - MAFE - 50 m on fault)
wang (Yongfei Wang - Generalized Finite Difference - SORD)
wzhang (Wenqiang Zhang - Mixed-Flux DG (200m~10km, O4))
yang (Hongfeng Yang - Finite Element - PyLith)

TPV37 – Off-Fault Station: body-090st200dp000



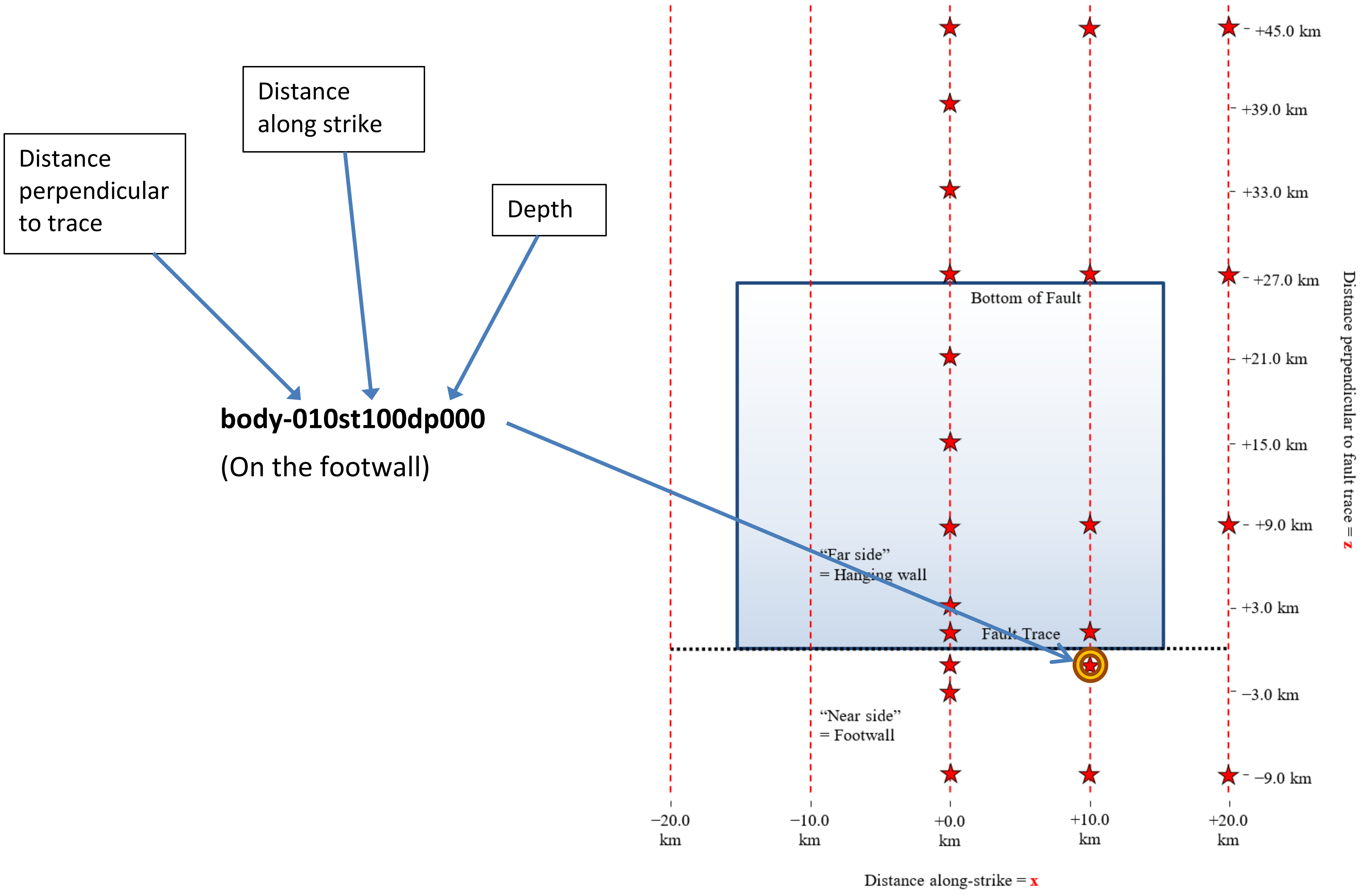


Metrics for velocity

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
(1) barall		86.2	11.9	11.1	9.5	12.3	40.0	34.7
(2) dliu	86.2		86.3	86.4	85.6	85.1	88.8	90.6
(3) kutschera.2	11.9	86.3		5.9	8.9	16.0	46.0	36.4
(4) li	11.1	86.4	5.9		10.1	17.0	47.1	33.8
(5) ma	9.5	85.6	8.9	10.1		8.0	39.1	35.0
(6) wang	12.3	85.1	16.0	17.0	8.0		31.7	37.3
(7) wzhang	40.0	88.8	46.0	47.1	39.1	31.7		56.7
(8) yang	34.7	90.6	36.4	33.8	35.0	37.3	56.7	

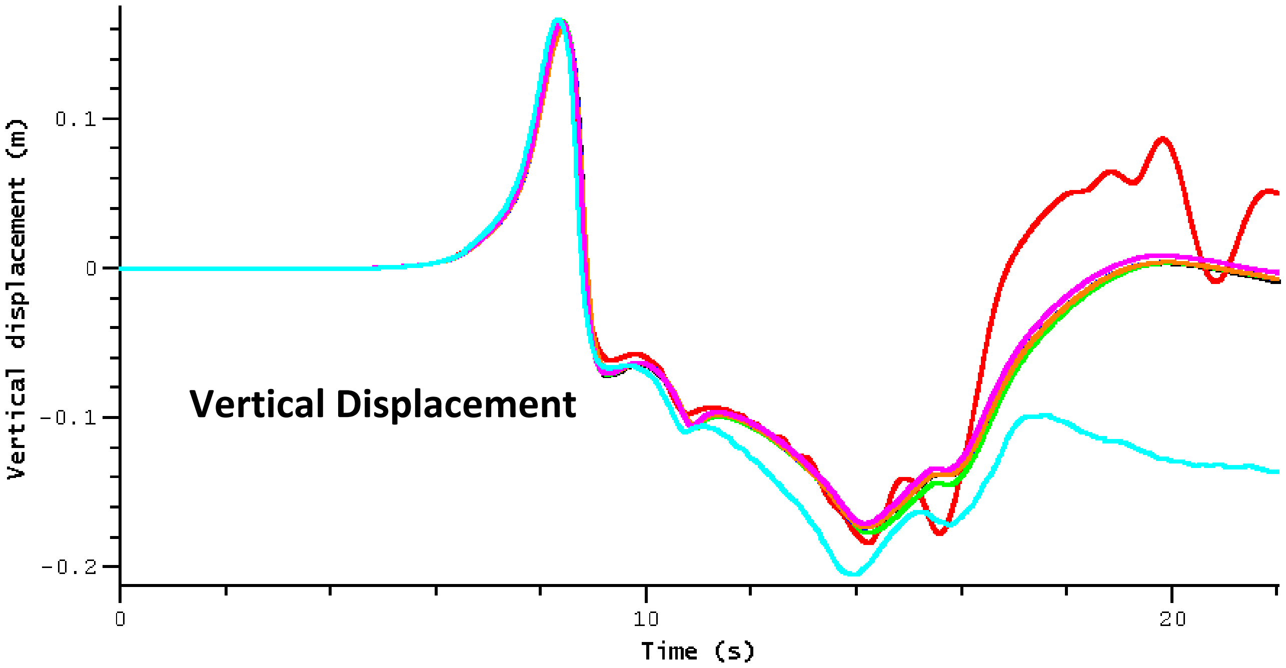
Normalized RMS difference (percent)

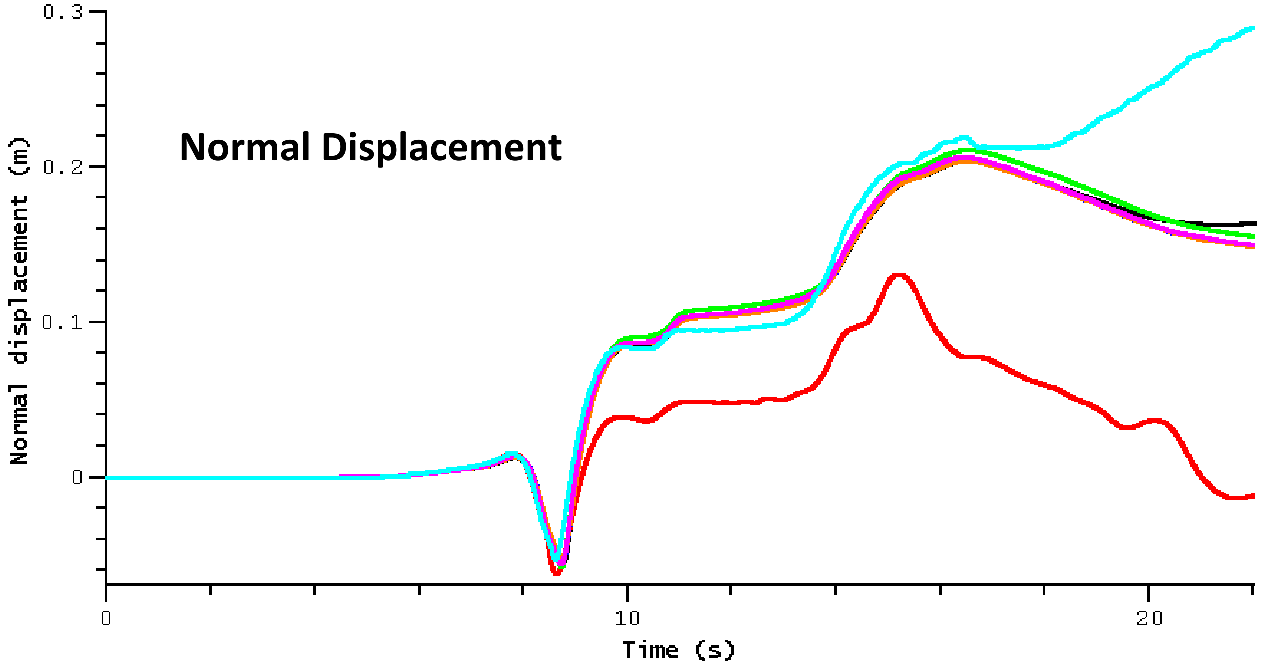
- barall (Michael Barall - FaultMod - 50 m)
- dliu (EQdyna.v5.3.3.50m.dliu)
- kutschera.2 (Fabian Kutschera - DG - SeisSol v1.2.0 - fault 200 m - o4)
- li (Duo Li - DG, h200,o4)
- ma (Shuo Ma - Finite Element - MAFE - 50 m on fault)
- wang (Yongfei Wang - Generalized Finite Difference - SORD)
- wzhang (Wenqiang Zhang - Mixed-Flux DG (200m~10km, O4))
- yang (Hongfeng Yang - Finite Element - PyLith)



Distance perpendicular to trace
Distance along strike
Depth
body-010st100dp000
(On the footwall)
+45.0 km
+39.0 km
+33.0 km
+27.0 km
Bottom of Fault
+21.0 km
+15.0 km
+9.0 km
"Far side"
= Hanging wall
+3.0 km
Fault Trace
−3.0 km
"Near side"
= Footwall
−9.0 km
−20.0 km
−10.0 km
+0.0 km
+10.0 km
+20.0 km
Distance along-strike = x
Distance perpendicular to fault trace = z

TPV36 – Off-Fault Station: body-010st100dp000





Metrics for displacement

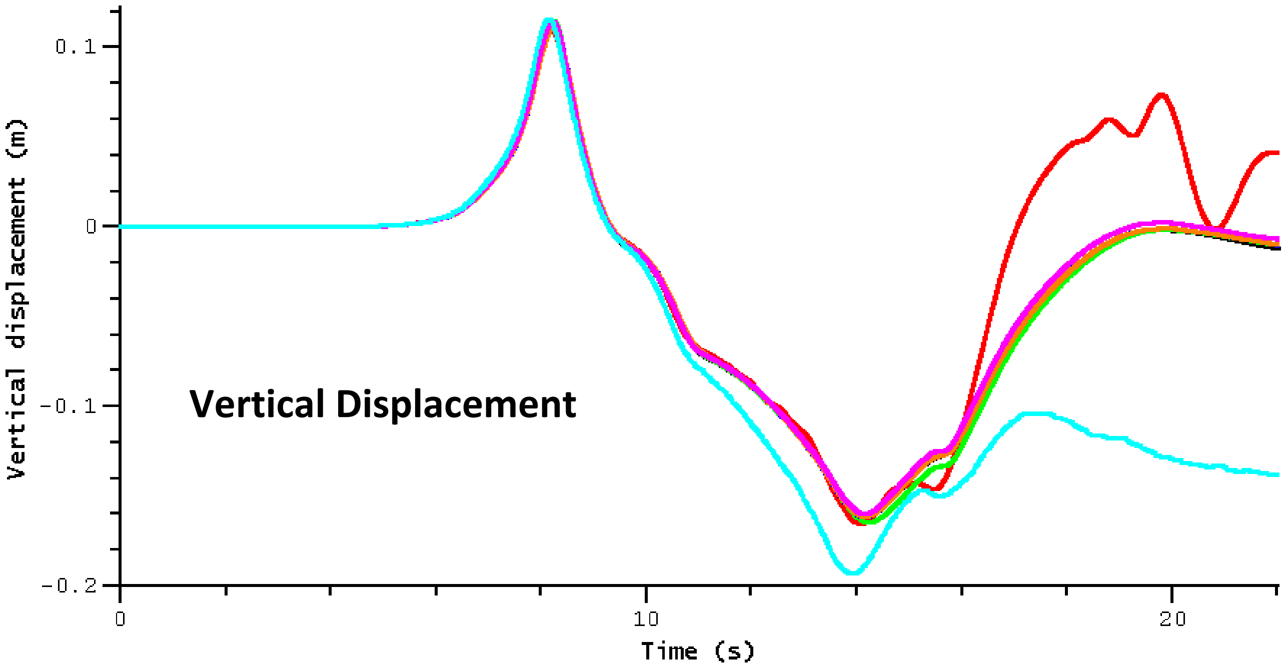
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
(1) barall		68.9	3.2	2.5	2.5	3.2	40.4
(2) dliu.2	68.9		69.8	67.6	67.6	67.9	96.9
(3) kutschera.2	3.2	69.8		3.7	3.8	4.3	40.0
(4) ma	2.5	67.6	3.7		0.4	2.3	41.9
(5) wang	2.5	67.6	3.8	0.4		2.4	41.9
(6) wzhang	3.2	67.9	4.3	2.3	2.4		43.1
(7) yang	40.4	96.9	40.0	41.9	41.9	43.1	

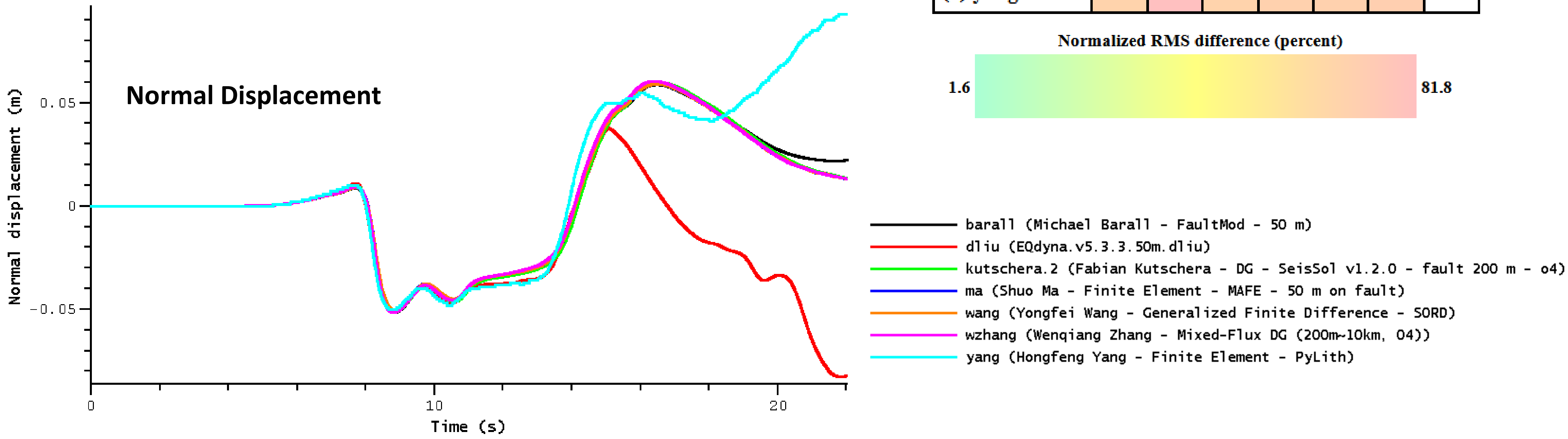
Normalized RMS difference (percent)

0.7 83.9

barall (Michael Barall - FaultMod - 50 m)
dliu.2 (EQdyna.v5.3.3.50m.dliu)
kutschera.2 (Fabian Kutschera - DG - SeisSol v1.2.0 - fault 200 m - o4)
ma (Shuo Ma - Finite Element - MAFE - 50 m on fault)
wang (Yongfei Wang - Generalized Finite Difference - SORD)
wzhang (Wenqiang Zhang - Mixed-Flux DG (200m~10km, O4))
yang (Hongfeng Yang - Finite Element - PyLith)

TPV37 – Off-Fault Station: body-010st100dp000



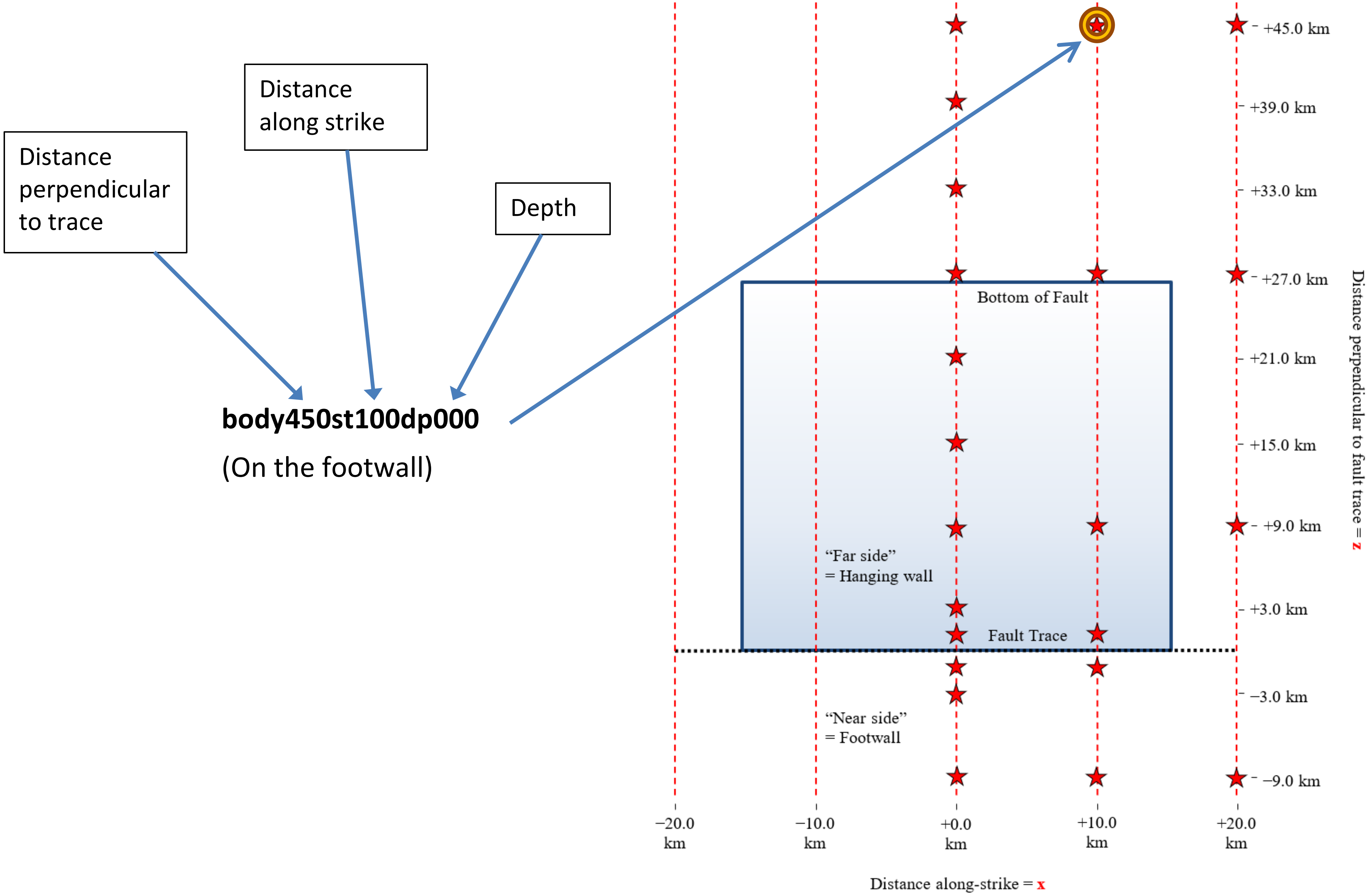


Metrics for displacement

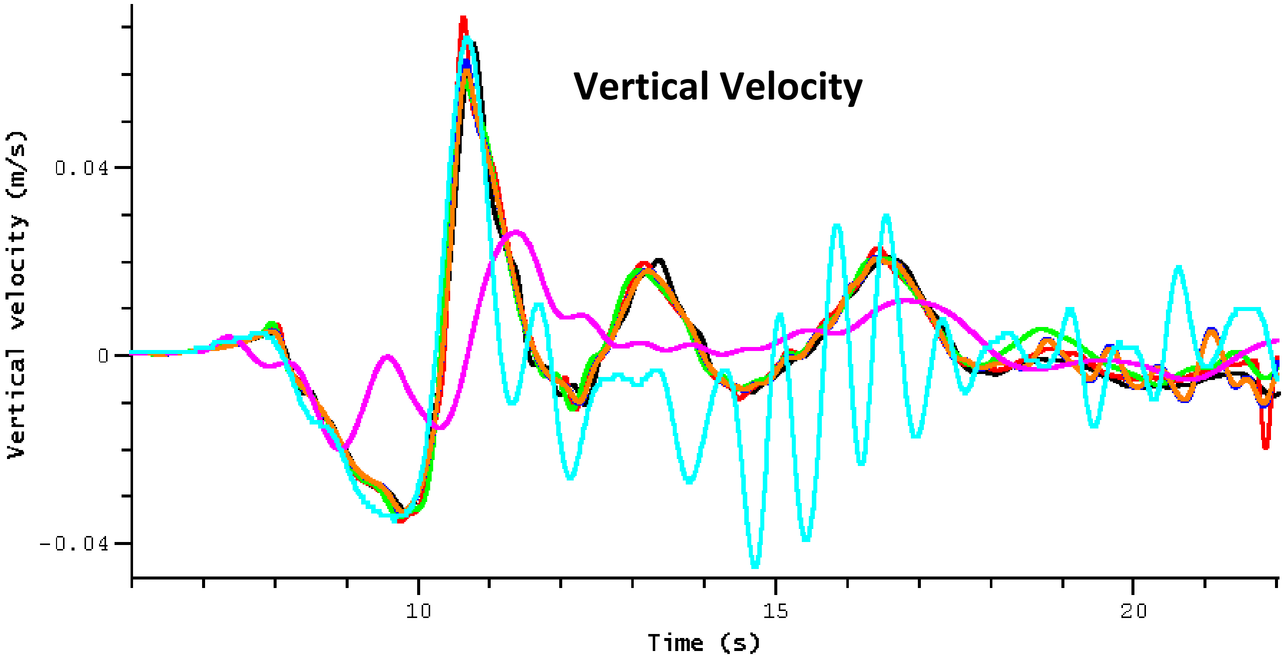
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
(1) barall		58.9	3.8	2.7	2.7	4.1	60.7
(2) dliu	58.9		57.8	57.4	57.4	56.9	99.4
(3) kutschera.2	3.8	57.8		3.6	3.6	5.5	60.6
(4) ma	2.7	57.4	3.6		0.2	2.7	62.1
(5) wang	2.7	57.4	3.6	0.2		2.7	62.1
(6) wzhang	4.1	56.9	5.5	2.7	2.7		64.1
(7) yang	60.7	99.4	60.6	62.1	62.1	64.1	

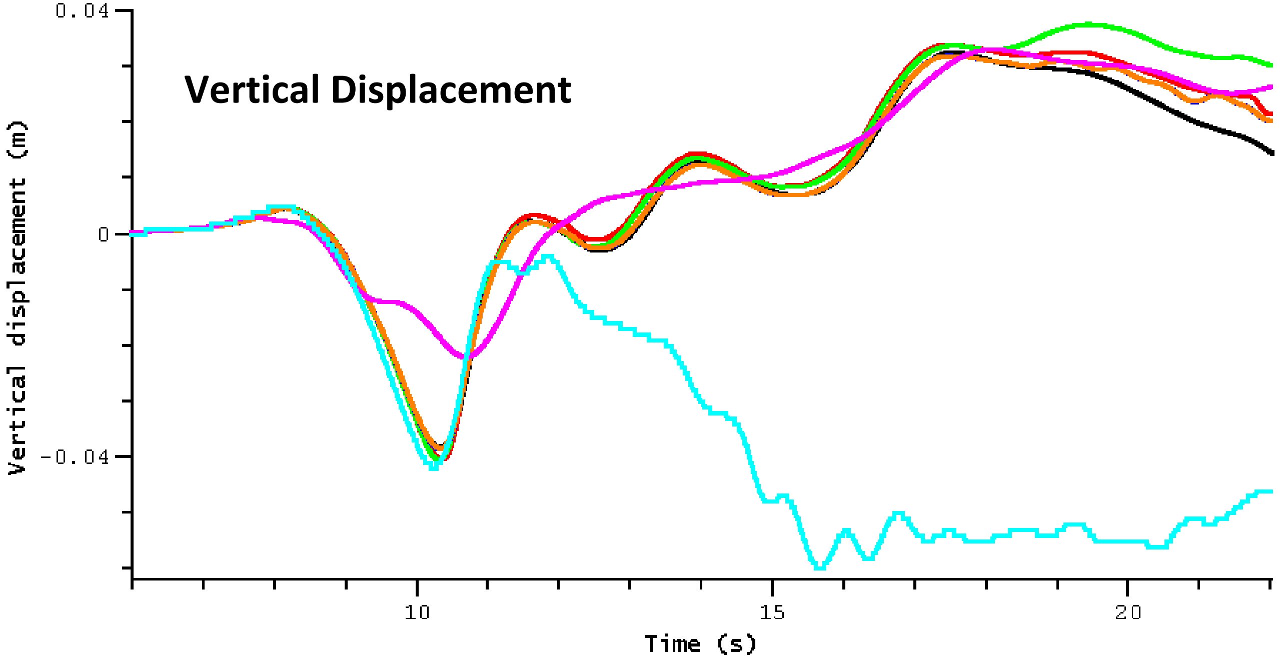
Normalized RMS difference (percent)

1.6 81.8


Distance perpendicular to trace
Distance along strike
Depth
body450st100dp000
(On the footwall)
+45.0 km
+39.0 km
+33.0 km
+27.0 km
+21.0 km
+15.0 km
+9.0 km
+3.0 km
−3.0 km
−9.0 km
Bottom of Fault
"Far side"
= Hanging wall
Fault Trace
"Near side"
= Footwall
−20.0 km
−10.0 km
+0.0 km
+10.0 km
+20.0 km
Distance along-strike = x
Distance perpendicular to fault trace = z

TPV36 – Off-Fault Station: body450st100dp000





Metrics for velocity

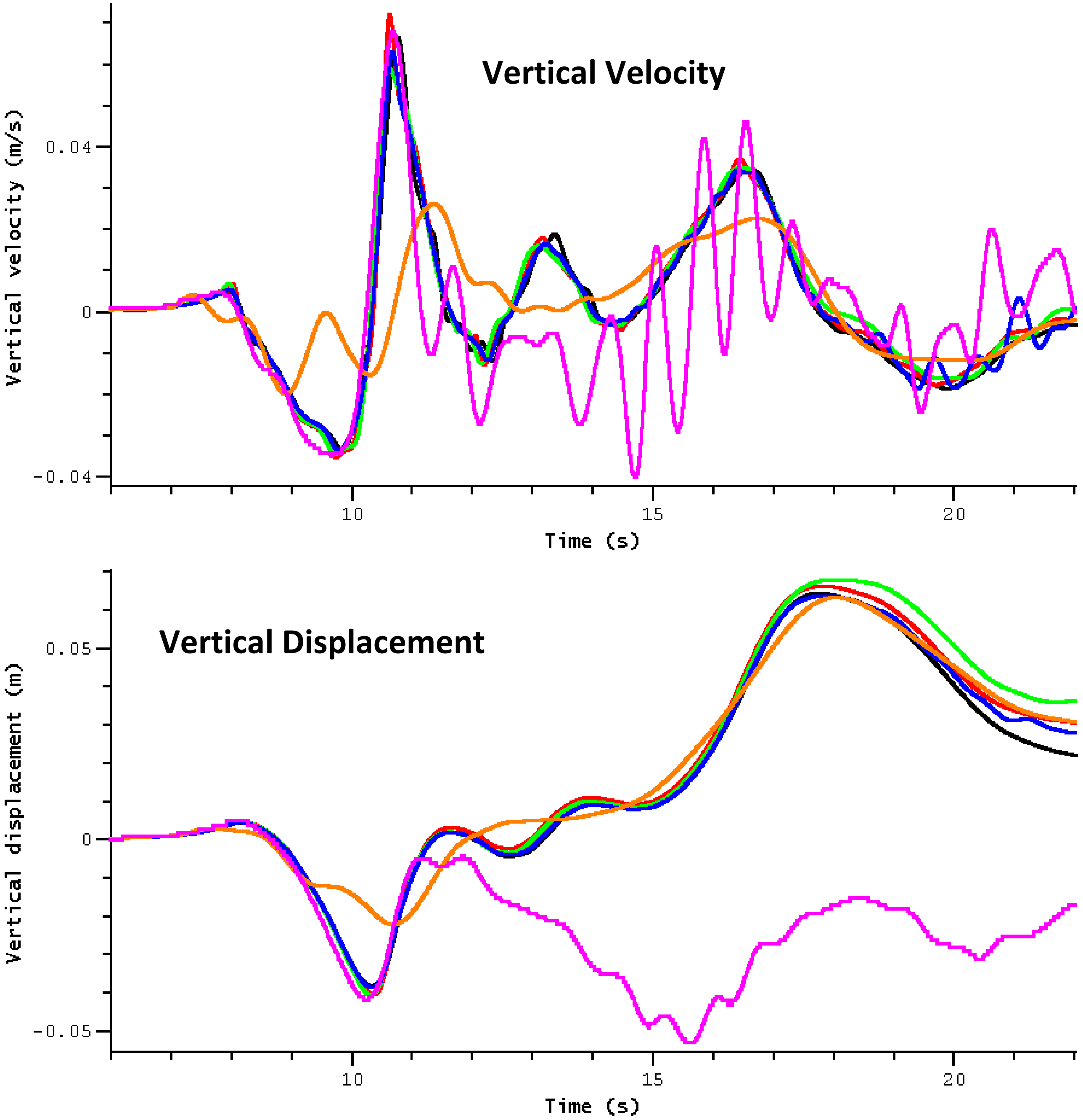
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
(1) barall		16.0	15.0	14.4	14.0	36.9	54.4
(2) kutschera.2	16.0		10.1	8.6	8.9	37.5	58.3
(3) li.2	15.0	10.1		11.5	11.4	37.9	56.2
(4) ma	14.4	8.6	11.5		1.3	35.4	58.0
(5) wang	14.0	8.9	11.4	1.3		34.9	57.9
(6) wzhang	36.9	37.5	37.9	35.4	34.9		66.2
(7) yang	54.4	58.3	56.2	58.0	57.9	66.2	

Normalized RMS difference (percent)

0.7 83.9

- barall (Michael Barall - FaultMod - 50 m)
- kutschera.2 (Fabian Kutschera - DG - SeisSol v1.2.0 - fault 200 m - o4)
- li.2 (Duo Li - DG FE, h=200m, O4)
- ma (Shuo Ma - Finite Element - MAFE - 50 m on fault)
- wang (Yongfei Wang - Generalized Finite Difference - SORD)
- wzhang (Wenqiang Zhang - Mixed-Flux DG (200m~10km, O4))
- yang (Hongfeng Yang - Finite Element - PyLith)

TPV37 – Off-Fault Station: body450st100dp000



Metrics for velocity

	(1)	(2)	(3)	(4)	(5)	(6)
(1) barall		15.4	14.6	14.0	37.0	56.5
(2) kutschera.2	15.4		9.9	8.1	37.5	59.8
(3) li	14.6	9.9		11.4	38.2	58.5
(4) ma	14.0	8.1	11.4		35.4	59.3
(5) wzhang	37.0	37.5	38.2	35.4		67.4
(6) yang	56.5	59.8	58.5	59.3	67.4	

Normalized RMS difference (percent)

1.6 **81.8**

barall (Michael Barall - FaultMod - 50 m)
kutschera.2 (Fabian Kutschera - DG - SeisSol v1.2.0 - fault 200 m - o4)
li (Duo Li - DG, h200,o4)
ma (Shuo Ma - Finite Element - MAFE - 50 m on fault)
wzhang (Wenqiang Zhang - Mixed-Flux DG (200m~10km, O4))
yang (Hongfeng Yang - Finite Element - PyLith)

On-Fault Stations: Time Series Data

Metric Comparison for Each Pair of Users: Summary Across All On-Fault Stations

TPV36

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
(1) barall		41.9	5.5	15.8	2.6	4.3	3.1	17.3
(2) dliu.2	41.9		43.7	55.5	41.3	41.6	41.5	47.0
(3) kutschera.2	5.5	43.7		15.4	5.6	7.2	5.3	19.5
(4) li.2	15.8	55.5	15.4		15.8	17.0	15.5	25.8
(5) ma	2.6	41.3	5.6	15.8		2.4	2.4	16.5
(6) wang	4.3	41.6	7.2	17.0	2.4		3.6	17.1
(7) wzhang	3.1	41.5	5.3	15.5	2.4	3.6		16.7
(8) yang	17.3	47.0	19.5	25.8	16.5	17.1	16.7	

Users	
(1) barall	Michael Barall - FaultMod - 50 m
(2) dliu.2	EQdyna.v5.3.3.50m.dliu
(3) kutschera.2	Fabian Kutschera - DG - SeisSol v1.2.0 - fault 200 m - o4
(4) li.2	Duo Li - DG FE,h=200m, O4
(5) ma	Shuo Ma - Finite Element - MAFE - 50 m on fault
(6) wang	Yongfei Wang - Generalized Finite Difference - SORD
(7) wzhang	Wenqiang Zhang - Mixed-Flux DG (200m~10km, O4)
(8) yang	Hongfeng Yang - Finite Element - PyLith

TPV37

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
(1) barall		6.9	4.7	14.7	1.6	3.6	2.7	18.3
(2) dliu	6.9		7.6	18.3	6.6	7.4	6.5	21.2
(3) kutschera.2	4.7	7.6		13.0	5.0	6.7	4.8	20.9
(4) li	14.7	18.3	13.0		15.0	16.1	14.8	27.2
(5) ma	1.6	6.6	5.0	15.0		2.7	2.4	18.2
(6) wang	3.6	7.4	6.7	16.1	2.7		3.4	18.7
(7) wzhang	2.7	6.5	4.8	14.8	2.4	3.4		18.5
(8) yang	18.3	21.2	20.9	27.2	18.2	18.7	18.5	

Users	
(1) barall	Michael Barall - FaultMod - 50 m
(2) dliu	EQdyna.v5.3.3.50m.dliu
(3) kutschera.2	Fabian Kutschera - DG - SeisSol v1.2.0 - fault 200 m - o4
(4) li	Duo Li - DG, h200,o4
(5) ma	Shuo Ma - Finite Element - MAFE - 50 m on fault
(6) wang	Yongfei Wang - Generalized Finite Difference - SORD
(7) wzhang	Wenqiang Zhang - Mixed-Flux DG (200m~10km, O4)
(8) yang	Hongfeng Yang - Finite Element - PyLith

The metric for two time series is the RMS difference between them, normalized to the range 0 to 200.

- Lower numbers are better; 0 is a perfect match, and values about 10 or less are a good match.
- We apply an optimum relative time shift when comparing, allowing for differences in propagation speed.

Metric Comparison for Each On-Fault Station: Summary Across All Users

TPV36

	2d-stress	2d-rate	2d-slip	t-shift
faultst000dp000	30.3	50.2	46.1	0.047
faultst000dp010	7.6	17.9	16.2	0.043
faultst000dp030	21.2	12.1	8.5	0.032
faultst000dp060	36.8	10.6	6.1	0.029
faultst000dp120	19.1	7.5	3.5	0.022
faultst000dp180	47.2	10.7	5.2	0.085
faultst000dp240	23.8	14.5	11.8	0.032
faultst040dp000	30.0	51.7	46.0	0.052
faultst040dp030	19.6	11.3	8.1	0.035
faultst040dp060	33.6	8.6	5.3	0.034
faultst040dp120	17.0	6.5	2.7	0.032
faultst040dp180	39.9	9.9	9.1	0.029
faultst080dp000	27.6	52.5	45.4	0.059
faultst080dp030	33.8	8.3	5.8	0.041
faultst080dp060	16.9	5.9	2.5	0.040
faultst080dp120	9.5	8.0	3.4	0.039
faultst080dp180	10.1	10.7	3.6	0.042
faultst120dp000	23.2	54.7	44.9	0.066
faultst120dp030	11.0	4.9	2.7	0.048
faultst120dp060	8.1	4.3	1.8	0.041
faultst120dp120	34.5	10.7	7.1	0.049
faultst120dp180	15.7	18.7	7.2	0.054

On Trace

Fields	
2d-stress	Shear stress vector
2d-rate	Slip rate vector
2d-slip	Slip vector
t-shift	Time shift

TPV37

	2d-stress	2d-rate	2d-slip	t-shift
faultst000dp000	14.9			0.045
faultst000dp010	9.1			0.062
faultst000dp030	11.7			0.362
faultst000dp060	28.7	10.6	6.9	0.026
faultst000dp120	9.9	6.8	3.3	0.019
faultst000dp180	31.7	8.8	4.4	0.048
faultst000dp240	16.6	14.7	9.9	0.032
faultst040dp000	14.5			0.048
faultst040dp030	9.7			0.175
faultst040dp060	21.4	6.6	3.2	0.028
faultst040dp120	10.2	6.1	2.4	0.031
faultst040dp180	43.3	8.9	8.9	0.026
faultst080dp000	13.7			0.050
faultst080dp030	7.3			0.069
faultst080dp060	12.0	5.0	2.2	0.035
faultst080dp120	9.9	7.1	2.7	0.038
faultst080dp180	10.1	9.8	2.6	0.042
faultst120dp000	15.0			0.060
faultst120dp030	6.5			0.054
faultst120dp060	10.7	4.0	1.5	0.041
faultst120dp120	23.4	10.1	3.2	0.050
faultst120dp180	11.3	18.1	6.3	0.054

On-Fault Stations	
faultst000dp000	strike 0.0 km, dip 0.0 km
faultst000dp010	strike 0.0 km, dip 1.0 km
faultst000dp030	strike 0.0 km, dip 3.0 km
faultst000dp060	strike 0.0 km, dip 6.0 km
faultst000dp120	strike 0.0 km, dip 12.0 km
faultst000dp180	strike 0.0 km, dip 18.0 km
faultst000dp240	strike 0.0 km, dip 24.0 km
faultst040dp000	strike 4.0 km, dip 0.0 km
faultst040dp030	strike 4.0 km, dip 3.0 km
faultst040dp060	strike 4.0 km, dip 6.0 km
faultst040dp120	strike 4.0 km, dip 12.0 km
faultst040dp180	strike 4.0 km, dip 18.0 km
faultst080dp000	strike 8.0 km, dip 0.0 km
faultst080dp030	strike 8.0 km, dip 3.0 km
faultst080dp060	strike 8.0 km, dip 6.0 km
faultst080dp120	strike 8.0 km, dip 12.0 km
faultst080dp180	strike 8.0 km, dip 18.0 km
faultst120dp000	strike 12.0 km, dip 0.0 km
faultst120dp030	strike 12.0 km, dip 3.0 km
faultst120dp060	strike 12.0 km, dip 6.0 km
faultst120dp120	strike 12.0 km, dip 12.0 km
faultst120dp180	strike 12.0 km, dip 18.0 km

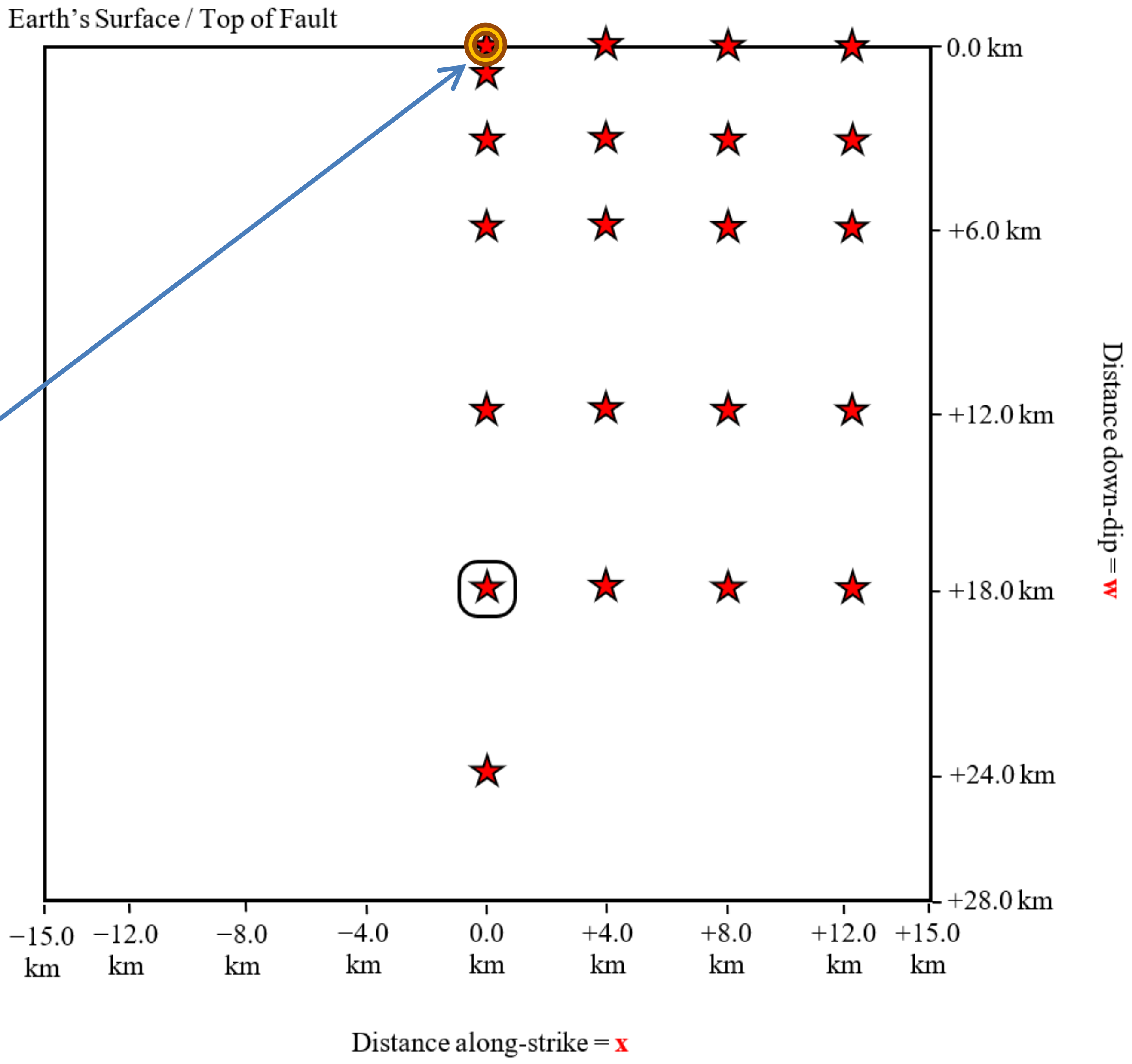
Distance along strike

Distance down-dip

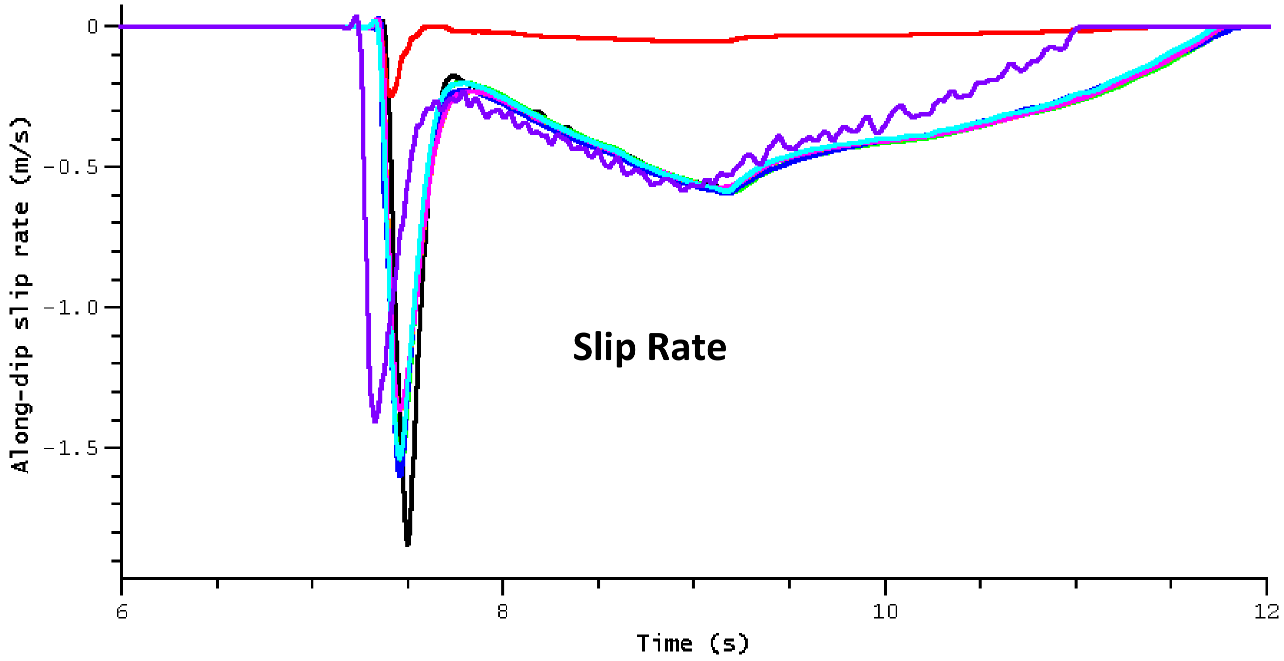
faultst000dp000

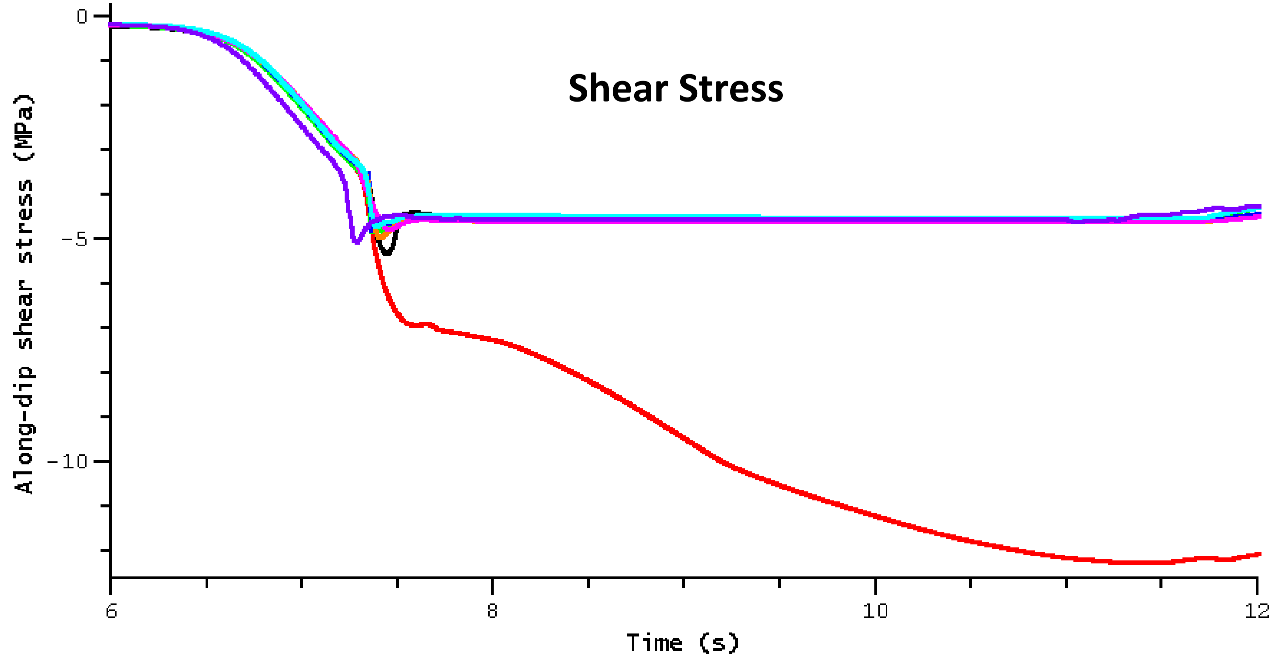
(On the fault trace, at the Earth's surface)

At a dip angle of 15 degrees, the depth is about 1/4 of the distance down-dip.



TPV36 – On-Fault Station: faultst000dp000





Metrics for slip rate

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
(1) barall		168.4	7.6	8.0	12.1	12.1	7.9	22.9
(2) dliu.2	168.4		168.4	168.7	167.8	167.8	167.6	166.2
(3) kutschera.2	7.6	168.4		4.1	8.0	8.0	5.7	22.4
(4) li.2	8.0	168.7	4.1		8.2	8.2	6.4	20.3
(5) ma	12.1	167.8	8.0	8.2		0.0	5.1	20.0
(6) wang	12.1	167.8	8.0	8.2	0.0		5.1	20.0
(7) wzhang	7.9	167.6	5.7	6.4	5.1	5.1		19.4
(8) yang	22.9	166.2	22.4	20.3	20.0	20.0	19.4	

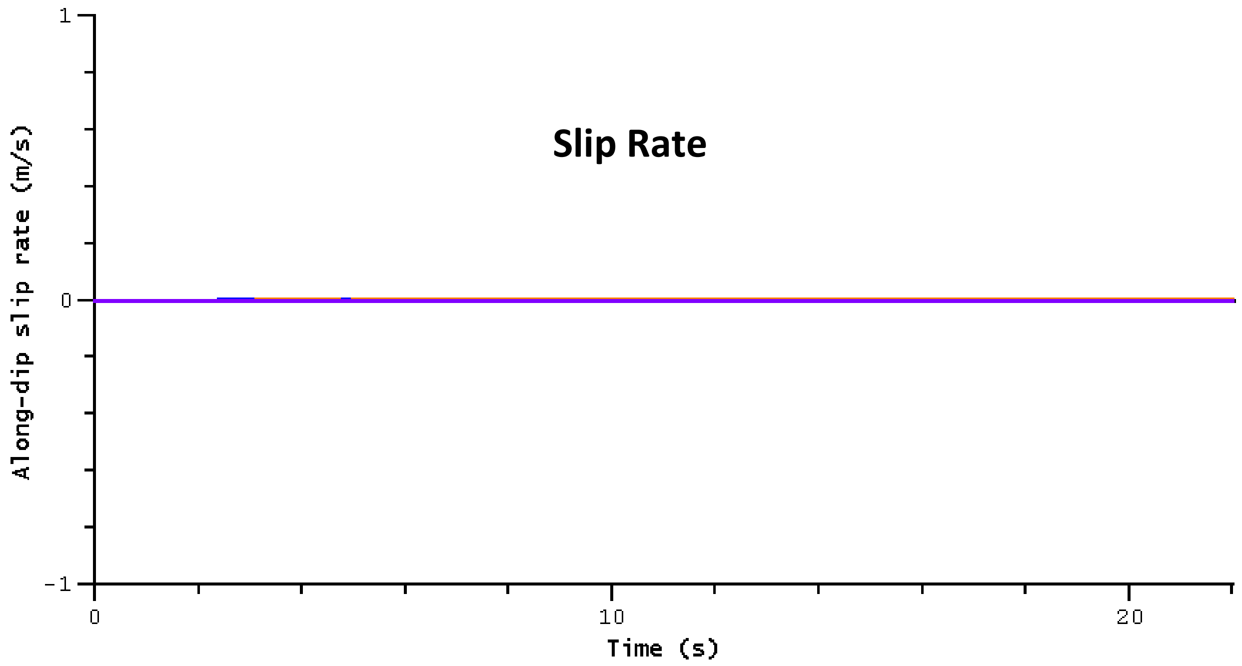
Normalized RMS difference (percent)

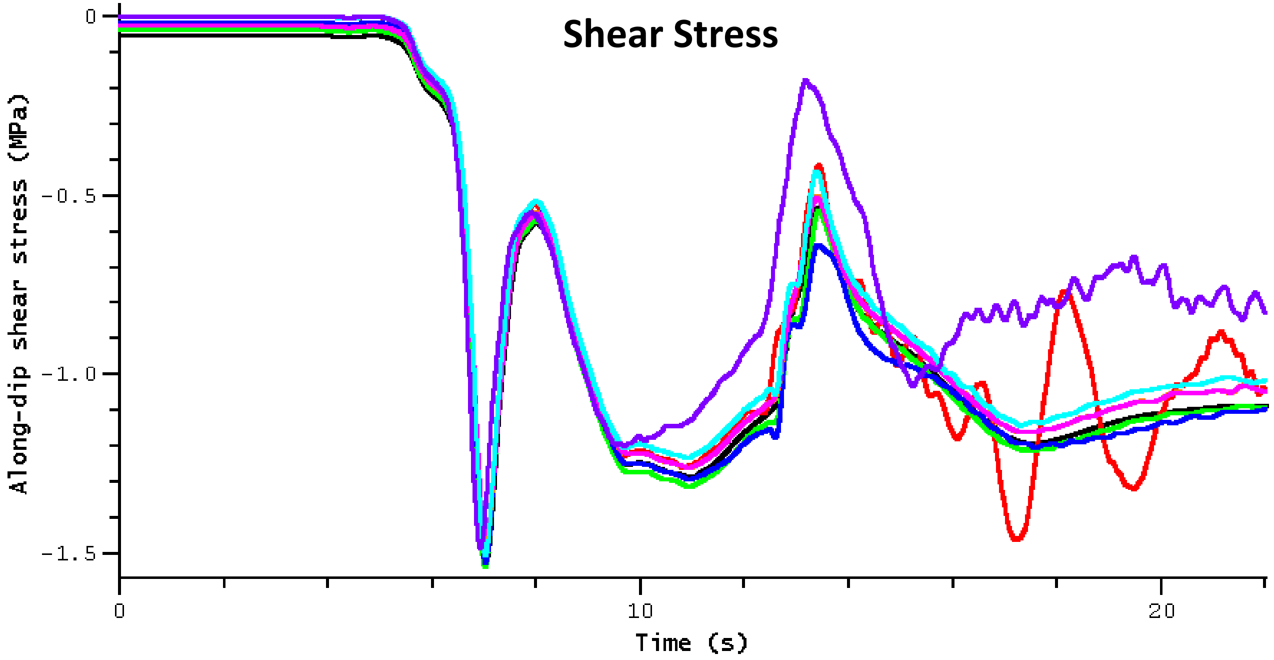
0.3 93.9

Slip rate and shear stress are low-pass filtered at 10 Hz

- barall (Michael Barall - FaultMod - 50 m)
- dliu.2 (EQdyna.v5.3.3.50m.dliu)
- kutschera.2 (Fabian Kutschera - DG - SeisSol v1.2.0 - fault 200 m - o4)
- li.2 (Duo Li - DG FE,h=200m, O4)
- ma (Shuo Ma - Finite Element - MAFE - 50 m on fault)
- wang (Yongfei Wang - Generalized Finite Difference - SORD)
- wzhang (Wenqiang Zhang - Mixed-Flux DG (200m~10km, O4))
- yang (Hongfeng Yang - Finite Element - PyLith)

TPV37 – On-Fault Station: faultst000dp000





Metrics for shear stress

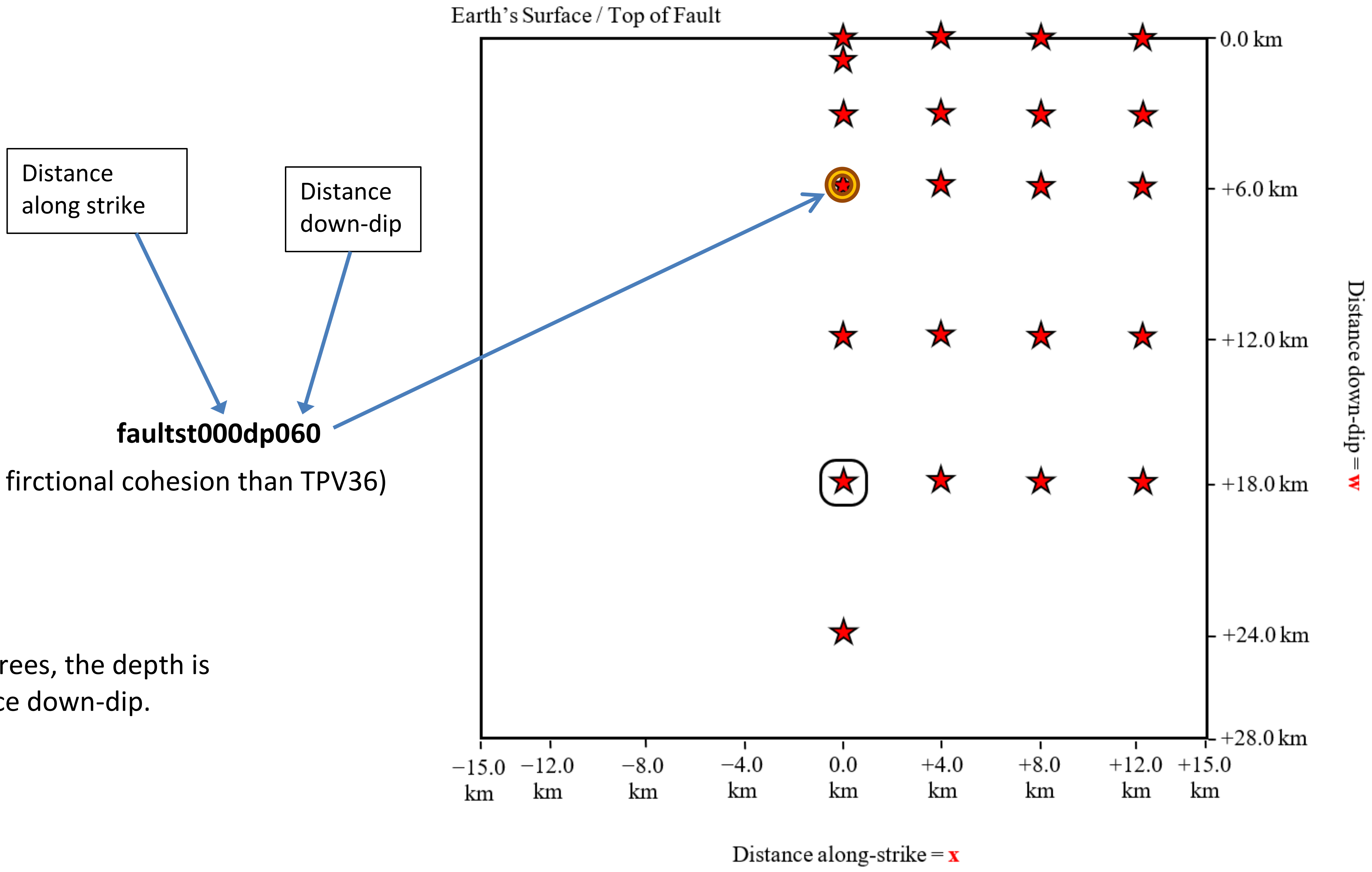
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
(1) barall		19.4	4.0	7.4	1.5	1.6	2.3	32.1
(2) dliu	19.4		19.2	20.2	19.3	19.3	19.1	37.5
(3) kutschera.2	4.0	19.2		5.0	4.6	4.7	4.4	34.1
(4) li	7.4	20.2	5.0		8.2	8.2	8.3	37.1
(5) ma	1.5	19.3	4.6	8.2		0.6	2.1	31.4
(6) wang	1.6	19.3	4.7	8.2	0.6		2.5	31.4
(7) wzhang	2.3	19.1	4.4	8.3	2.1	2.5		31.2
(8) yang	32.1	37.5	34.1	37.1	31.4	31.4	31.2	

Normalized RMS difference (percent)

0.5 — 32.9

Slip rate and shear stress are low-pass filtered at 10 Hz

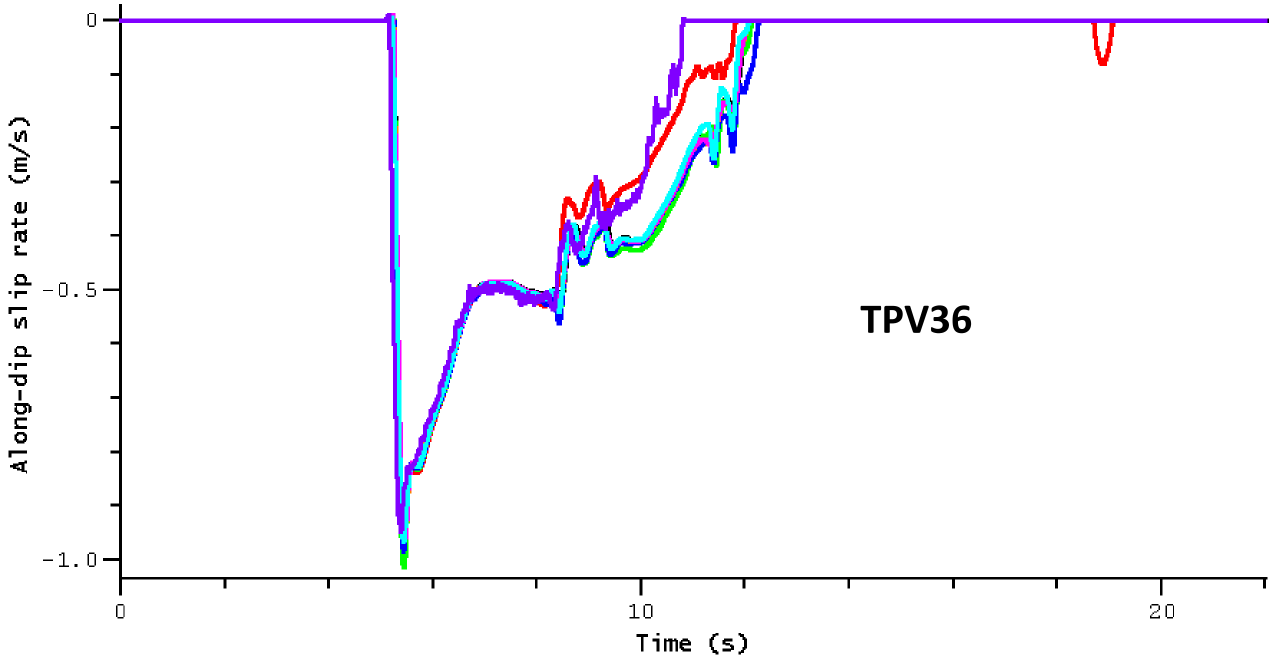
- barall (Michael Barall - FaultMod - 50 m)
- dliu (EQdyna.v5.3.3.50m.dliu)
- kutschera.2 (Fabian Kutschera - DG - SeisSol v1.2.0 - fault 200 m - o4)
- li (Duo Li - DG, h200,o4)
- ma (Shuo Ma - Finite Element - MAFE - 50 m on fault)
- wang (Yongfei Wang - Generalized Finite Difference - SORD)
- wzhang (Wenqiang Zhang - Mixed-Flux DG (200m~10km, O4))
- yang (Hongfeng Yang - Finite Element - PyLith)



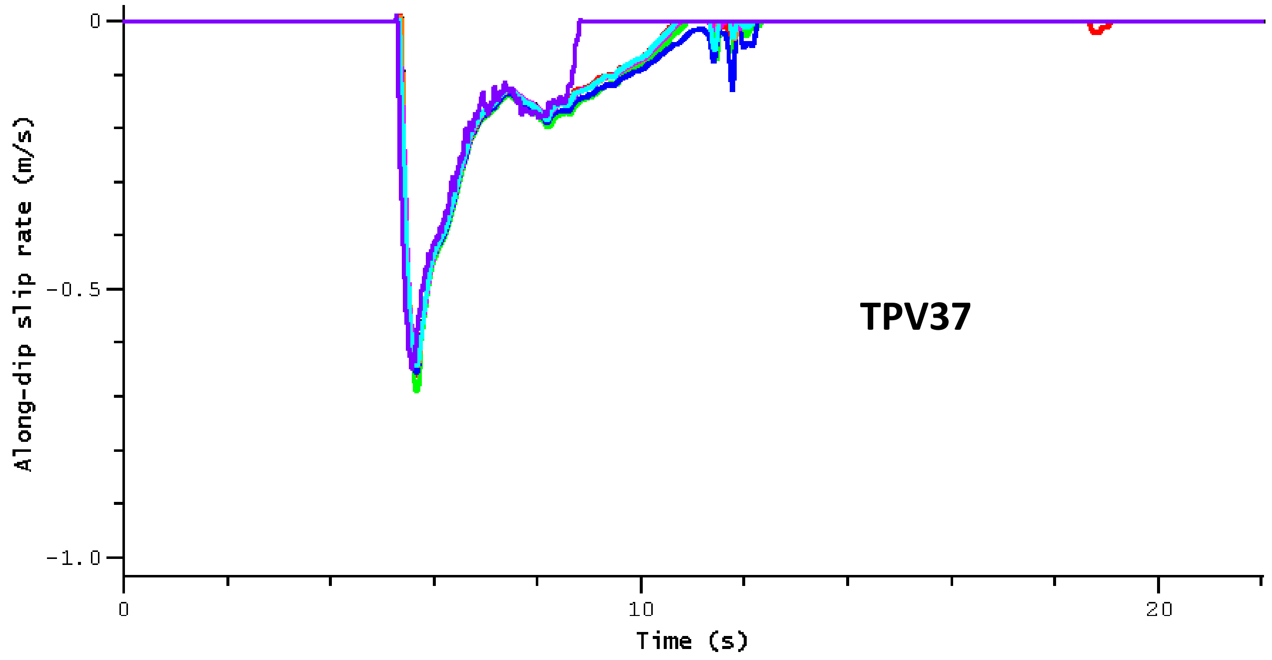
(TPV37 has higher firctional cohesion than TPV36)

At a dip angle of 15 degrees, the depth is about 1/4 of the distance down-dip.

On-Fault Station: faultst000dp060 – <u>Slip Rate</u>



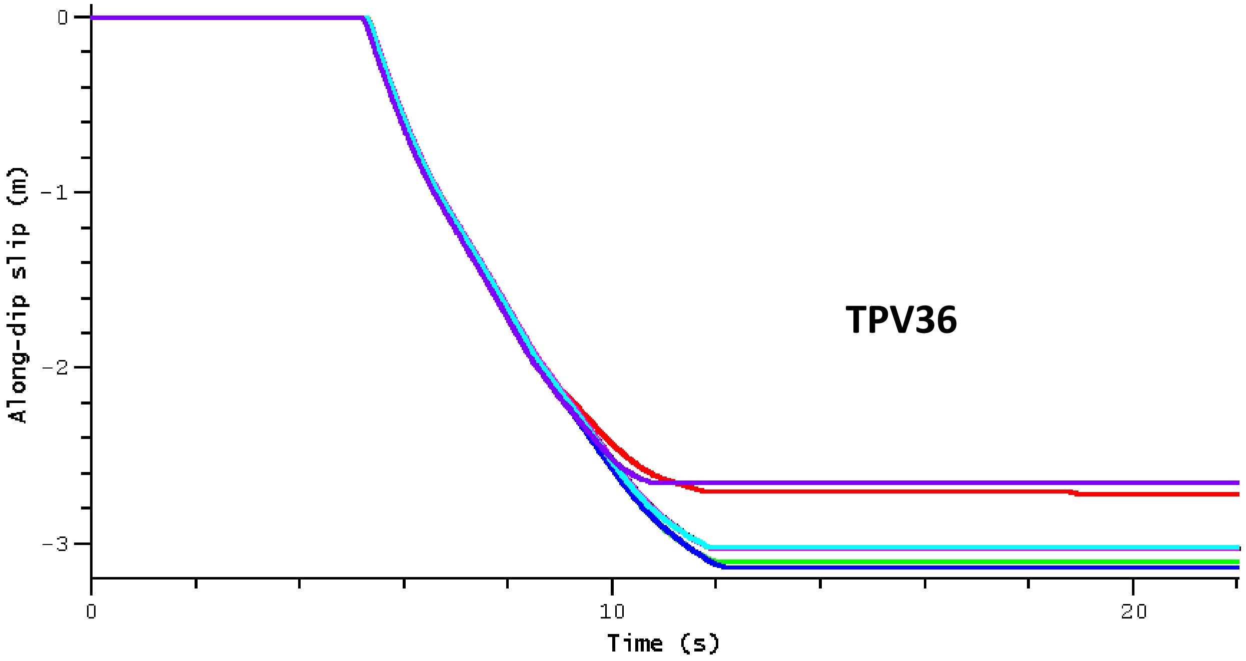
- baral1 (Michael Barall - FaultMod - 50 m)
- dliu.2 (EQdyna.v5.3.3.50m.dliu)
- kutschera.2 (Fabian Kutschera - DG - SeisSol v1.2.0 - fault 200 m - o4)
- li.2 (Duo Li - DG FE,h=200m, 04)
- ma (Shuo Ma - Finite Element - MAFE - 50 m on fault)
- wang (Yongfei Wang - Generalized Finite Difference - SORD)
- wzhang (Wenqiang Zhang - Mixed-Flux DG (200m~10km, 04))
- yang (Hongfeng Yang - Finite Element - PyLith)



Slip rate and shear stress are low-pass filtered at 10 Hz

- baral1 (Michael Barall - FaultMod - 50 m)
- dliu (EQdyna.v5.3.3.50m.dliu)
- kutschera.2 (Fabian Kutschera - DG - SeisSol v1.2.0 - fault 200 m - o4)
- li (Duo Li - DG, h200,o4)
- ma (Shuo Ma - Finite Element - MAFE - 50 m on fault)
- wang (Yongfei Wang - Generalized Finite Difference - SORD)
- wzhang (Wenqiang Zhang - Mixed-Flux DG (200m~10km, 04))
- yang (Hongfeng Yang - Finite Element - PyLith)

On-Fault Station: faultst000dp060 – Slip



baral1 (Michael Barall - FaultMod - 50 m)
dliu.2 (EQdyna.v5.3.3.50m.dliu)
kutschera.2 (Fabian Kutschera - DG - SeisSol v1.2.0 - fault 200 m - o4)
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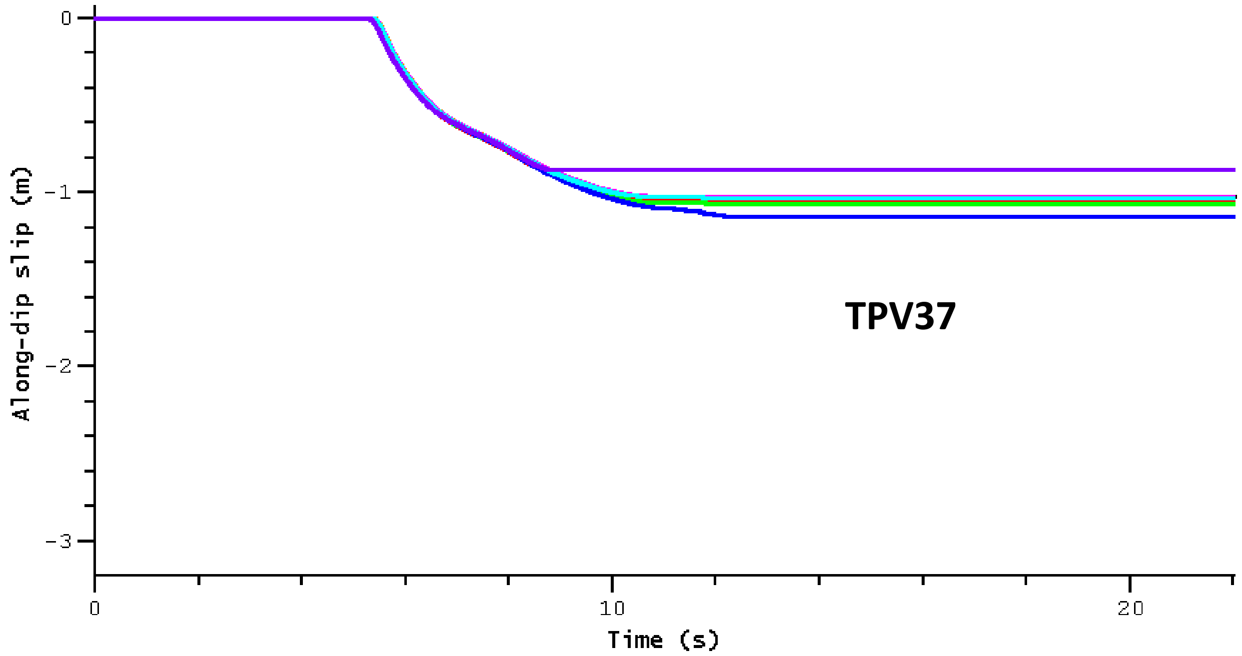
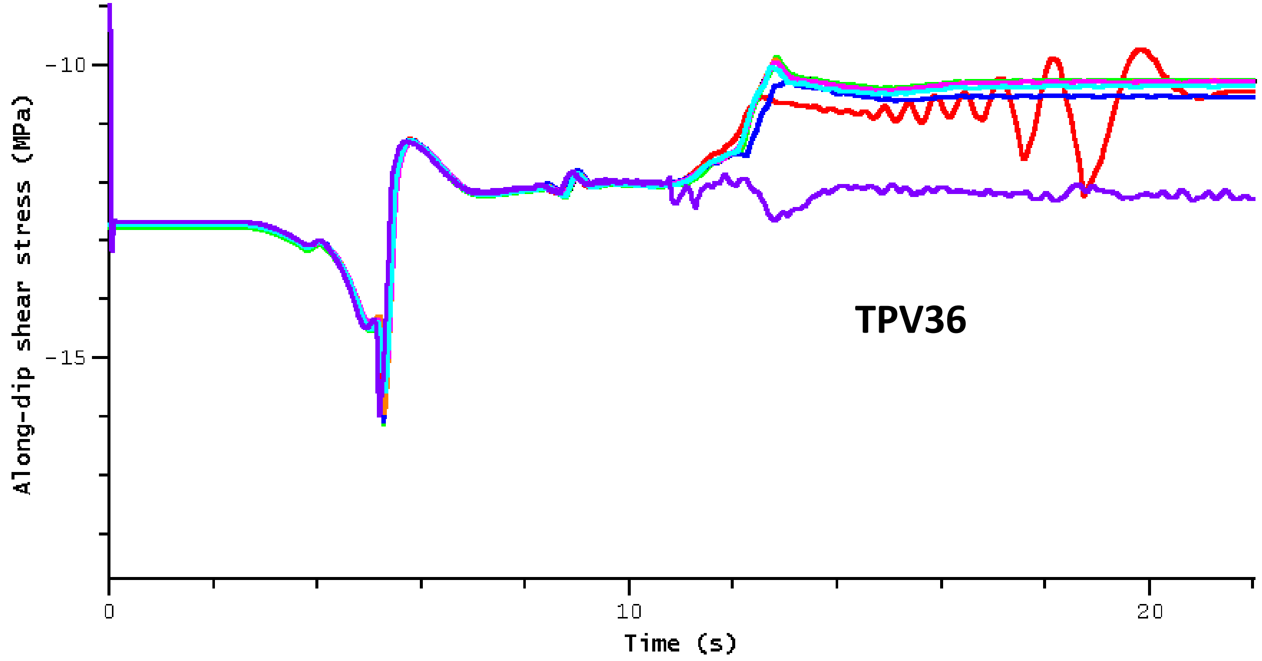


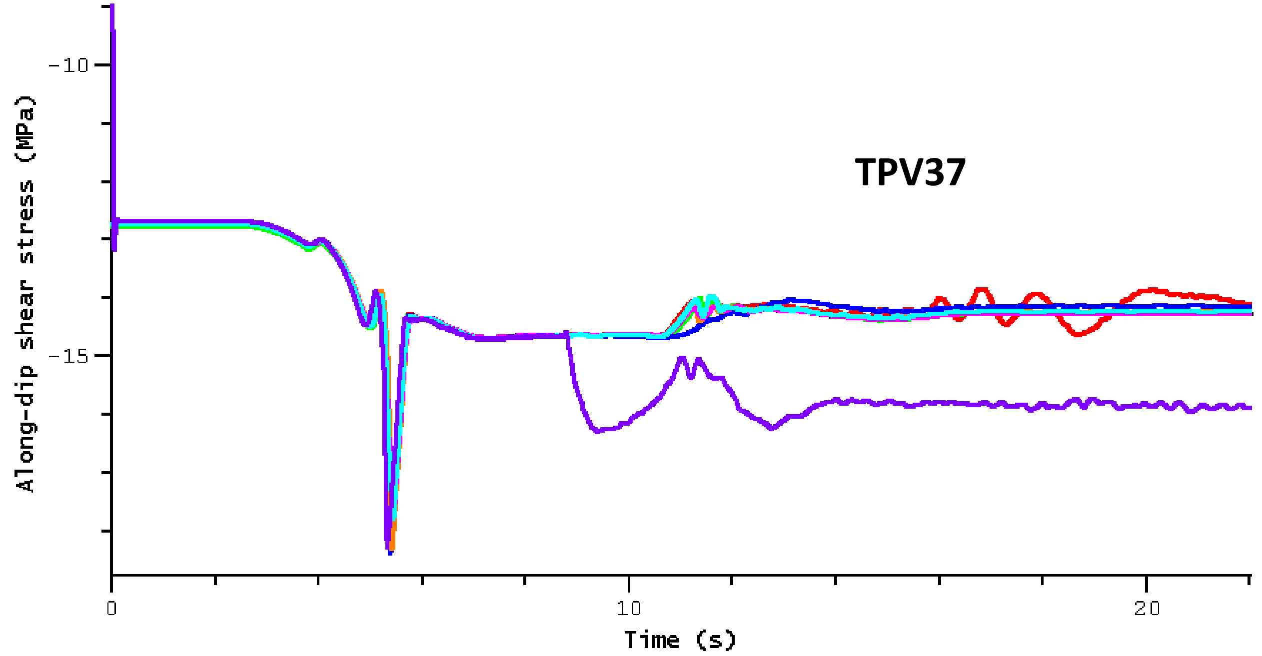
Slip rate and shear stress are low-pass filtered at 10 Hz

baral1 (Michael Barall - FaultMod - 50 m)
dliu (EQdyna.v5.3.3.50m.dliu)
kutschera.2 (Fabian Kutschera - DG - SeisSol v1.2.0 - fault 200 m - o4)
li (Duo Li - DG, h200,o4)
ma (Shuo Ma - Finite Element - MAFE - 50 m on fault)
wang (Yongfei Wang - Generalized Finite Difference - SORD)
wzhang (Wenqiang Zhang - Mixed-Flux DG (200m~10km, O4))
yang (Hongfeng Yang - Finite Element - PyLith)

On-Fault Station: faultst000dp060 – Shear Stress



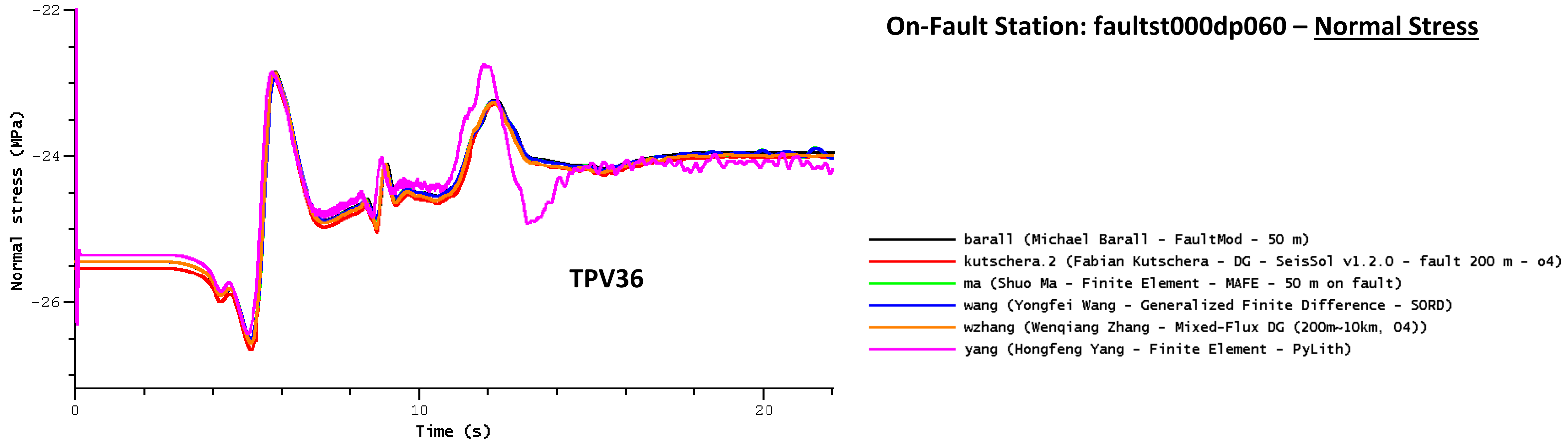
baral1 (Michael Barall - FaultMod - 50 m)
dliu.2 (EQdyna.v5.3.3.50m.dliu)
kutschera.2 (Fabian Kutschera - DG - SeisSol v1.2.0 - fault 200 m - o4)
li.2 (Duo Li - DG FE,h=200m, O4)
ma (Shuo Ma - Finite Element - MAFE - 50 m on fault)
wang (Yongfei Wang - Generalized Finite Difference - SORD)
wzhang (Wenqiang Zhang - Mixed-Flux DG (200m~10km, O4))
yang (Hongfeng Yang - Finite Element - PyLith)

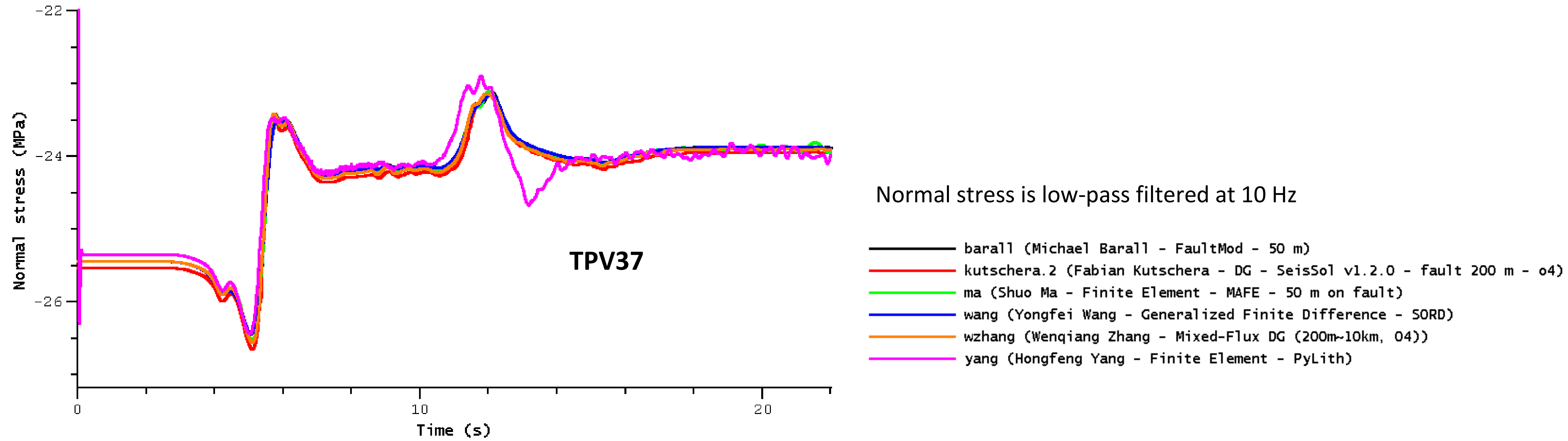


Slip rate and shear stress are low-pass filtered at 10 Hz

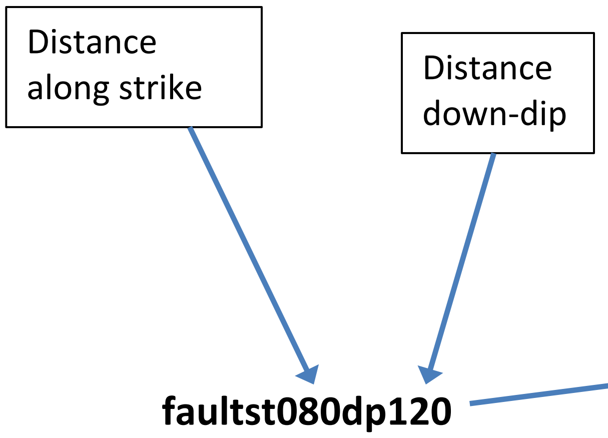
baral1 (Michael Barall - FaultMod - 50 m)
dliu (EQdyna.v5.3.3.50m.dliu)
kutschera.2 (Fabian Kutschera - DG - SeisSol v1.2.0 - fault 200 m - o4)
li (Duo Li - DG, h200,o4)
ma (Shuo Ma - Finite Element - MAFE - 50 m on fault)
wang (Yongfei Wang - Generalized Finite Difference - SORD)
wzhang (Wenqiang Zhang - Mixed-Flux DG (200m~10km, O4))
yang (Hongfeng Yang - Finite Element - PyLith)

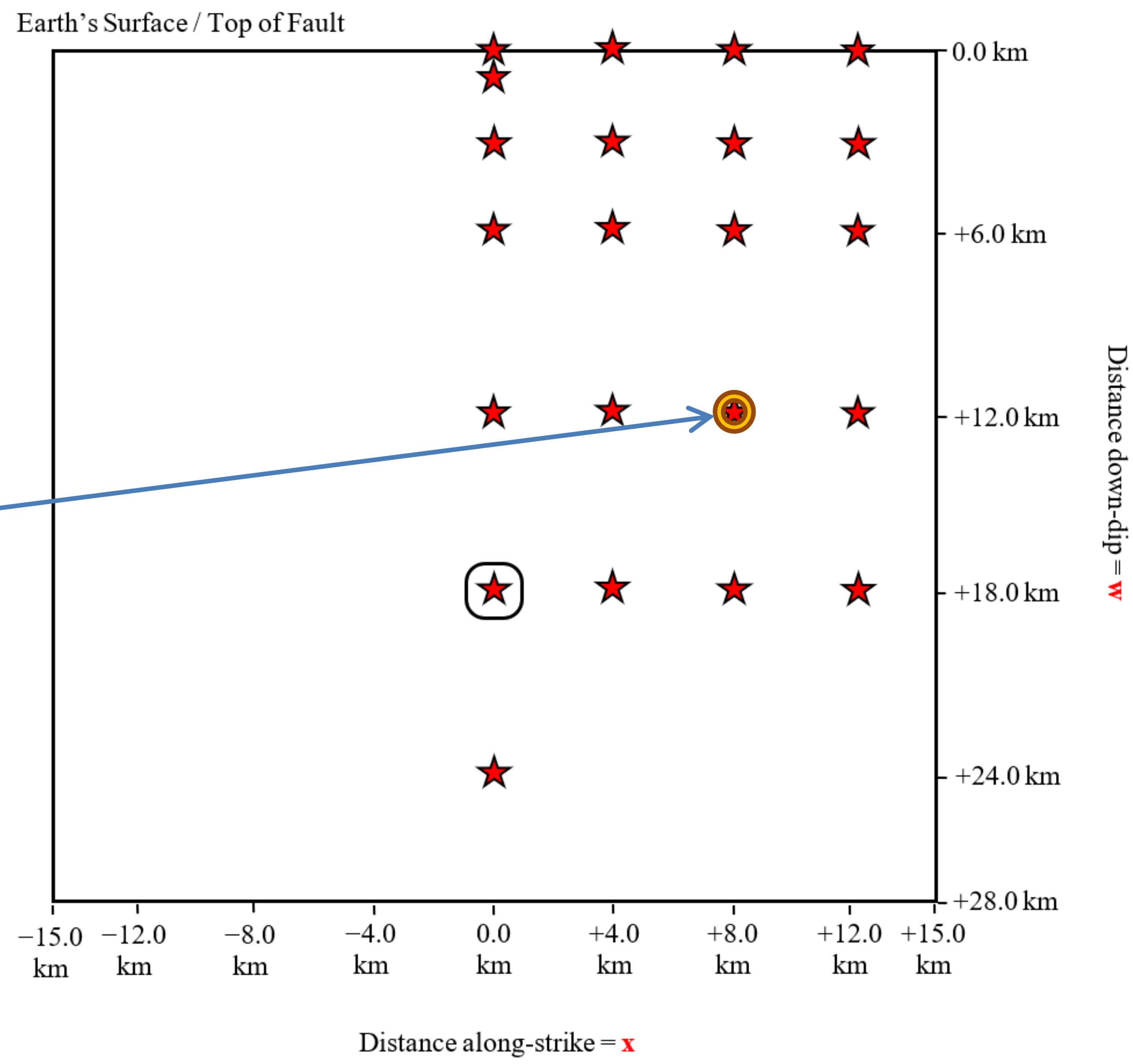
On-Fault Station: faultst000dp060 – Normal Stress



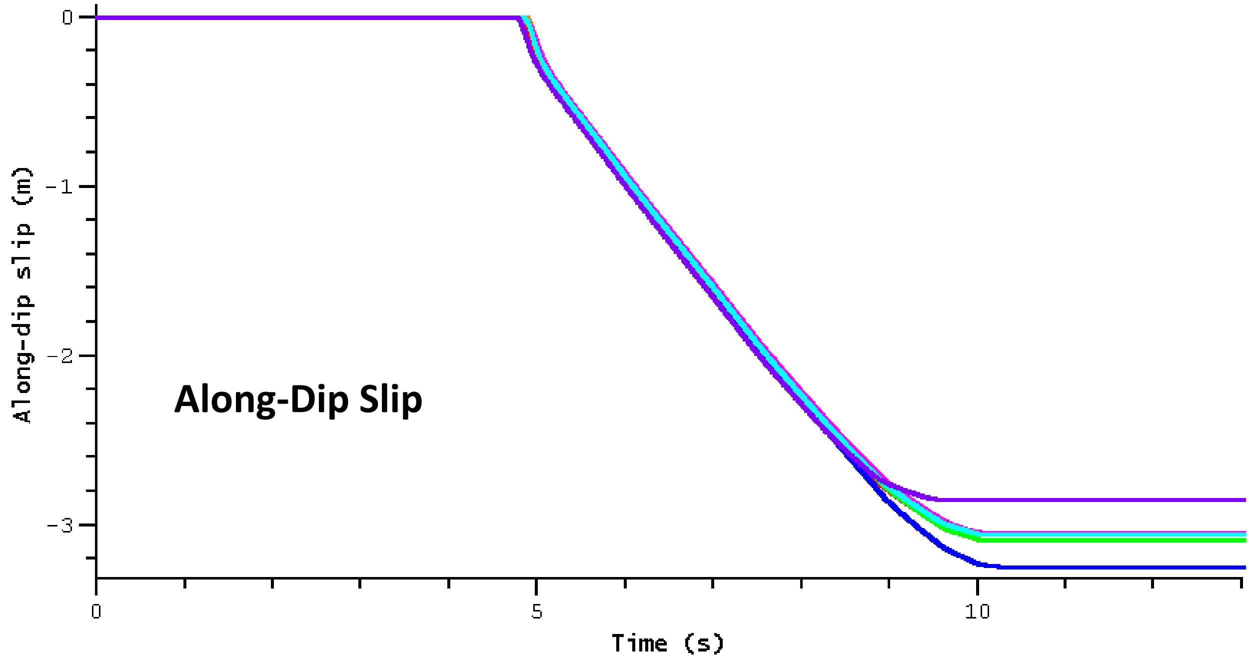


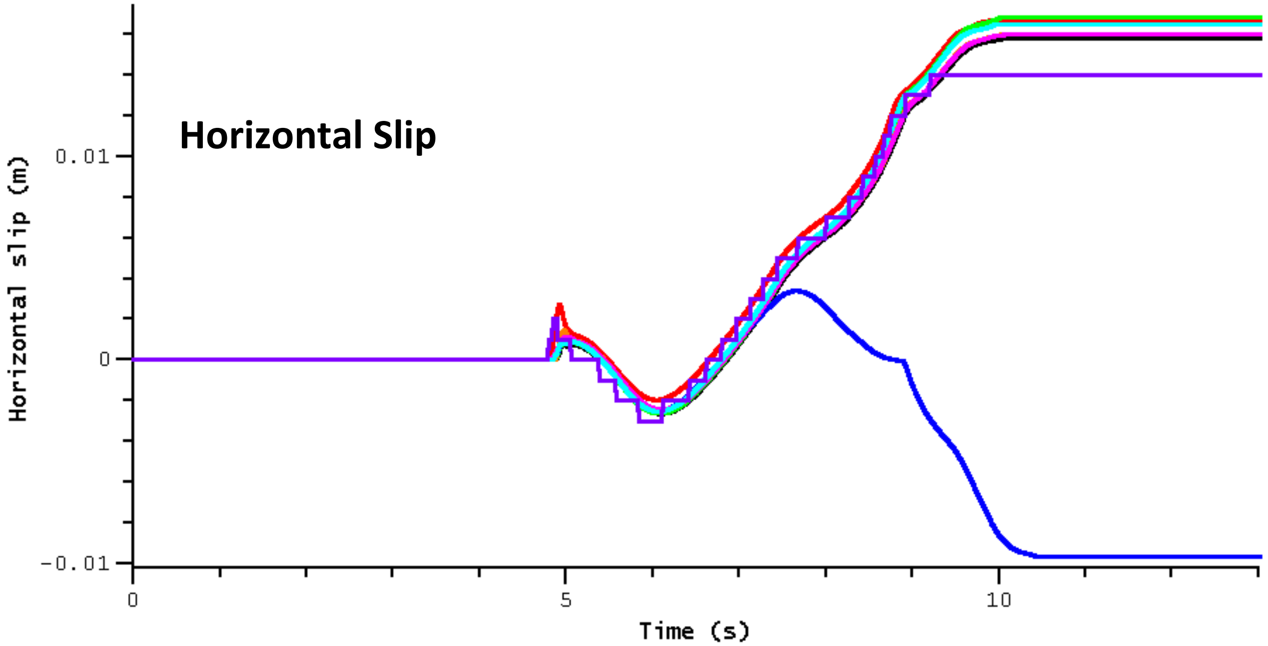
Normal stress is low-pass filtered at 10 Hz





At a dip angle of 15 degrees, the depth is about 1/4 of the distance down-dip.





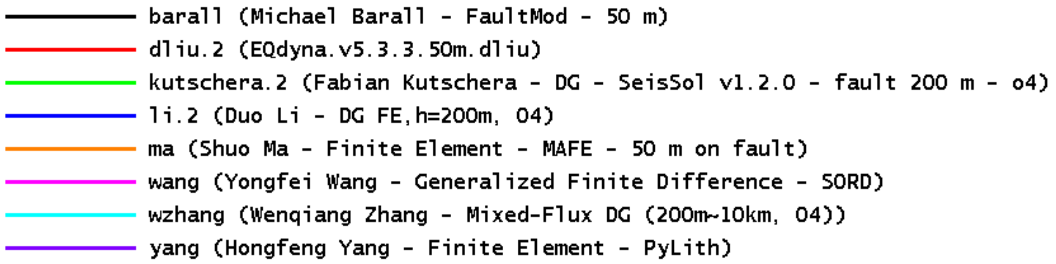
TPV36 – On-Fault Station: faultst080dp120

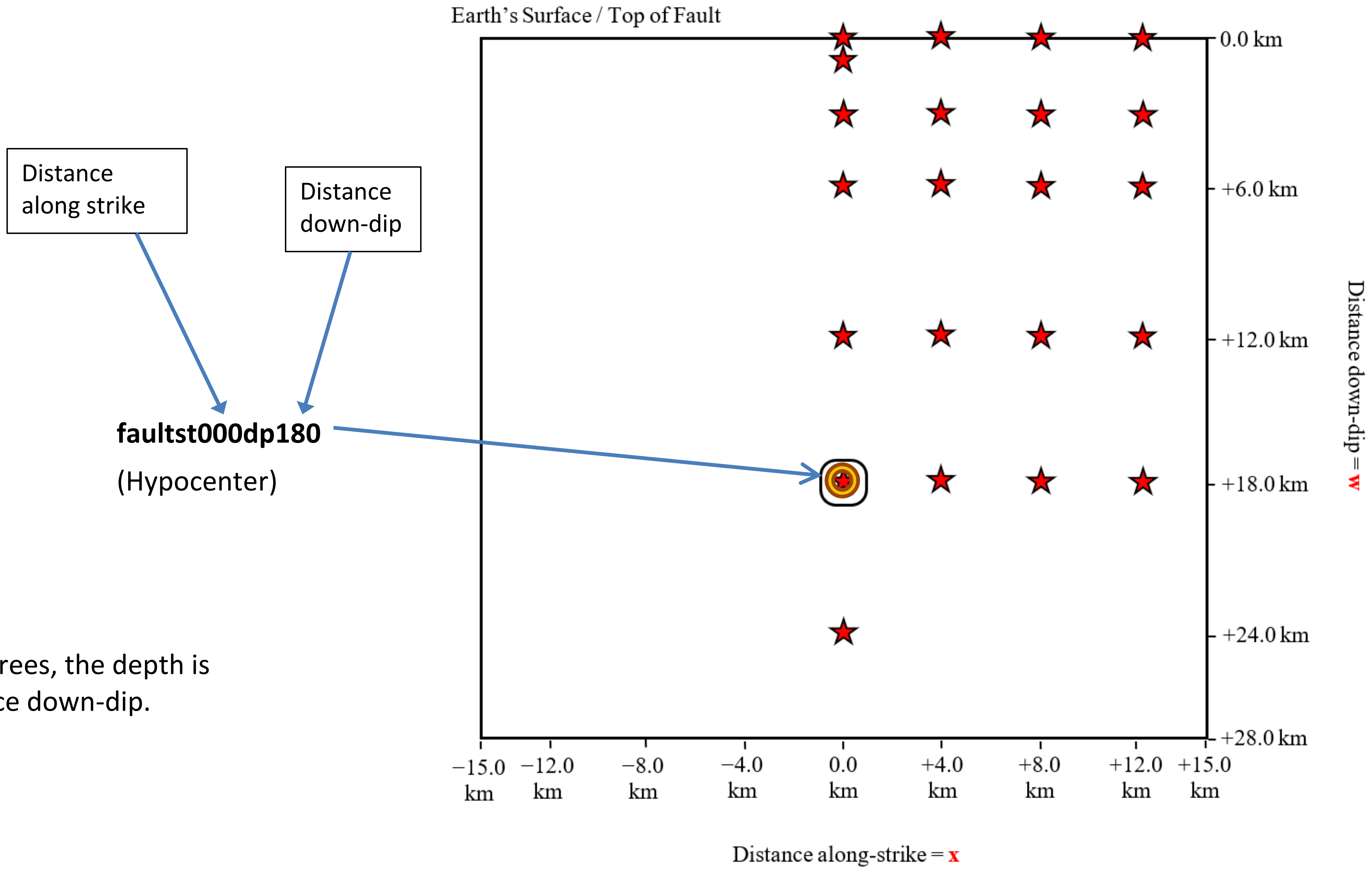
Metrics for slip rate

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
(1) barall		4.4	4.6	6.7	2.4	8.4	3.8	12.7
(2) dliu.2	4.4		7.5	9.3	3.0	5.4	3.2	11.9
(3) kutschera.2	4.6	7.5		4.1	5.8	11.0	6.4	14.6
(4) li.2	6.7	9.3	4.1		7.7	12.4	8.2	17.2
(5) ma	2.4	3.0	5.8	7.7		6.5	2.0	12.3
(6) wang	8.4	5.4	11.0	12.4	6.5		5.8	13.7
(7) wzhang	3.8	3.2	6.4	8.2	2.0	5.8		12.0
(8) yang	12.7	11.9	14.6	17.2	12.3	13.7	12.0	

Normalized RMS difference (percent)

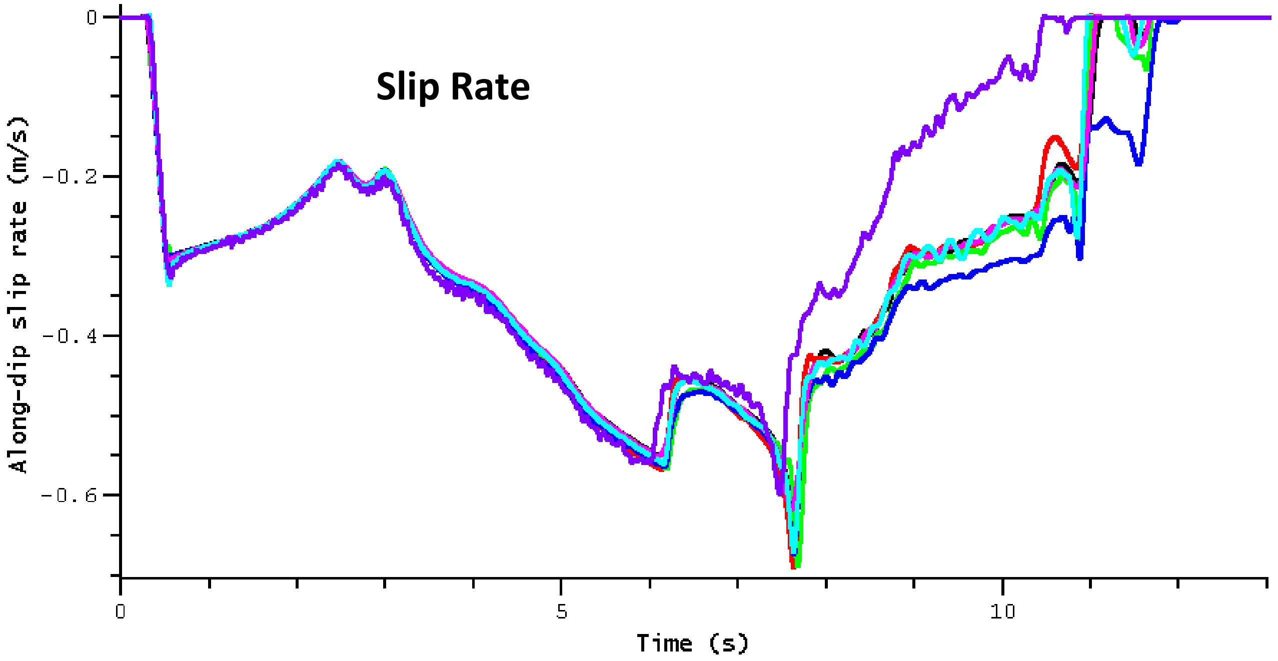
Slip rate and shear stress are low-pass filtered at 10 Hz





At a dip angle of 15 degrees, the depth is about 1/4 of the distance down-dip.

TPV36 – On-Fault Station: faultst000dp180

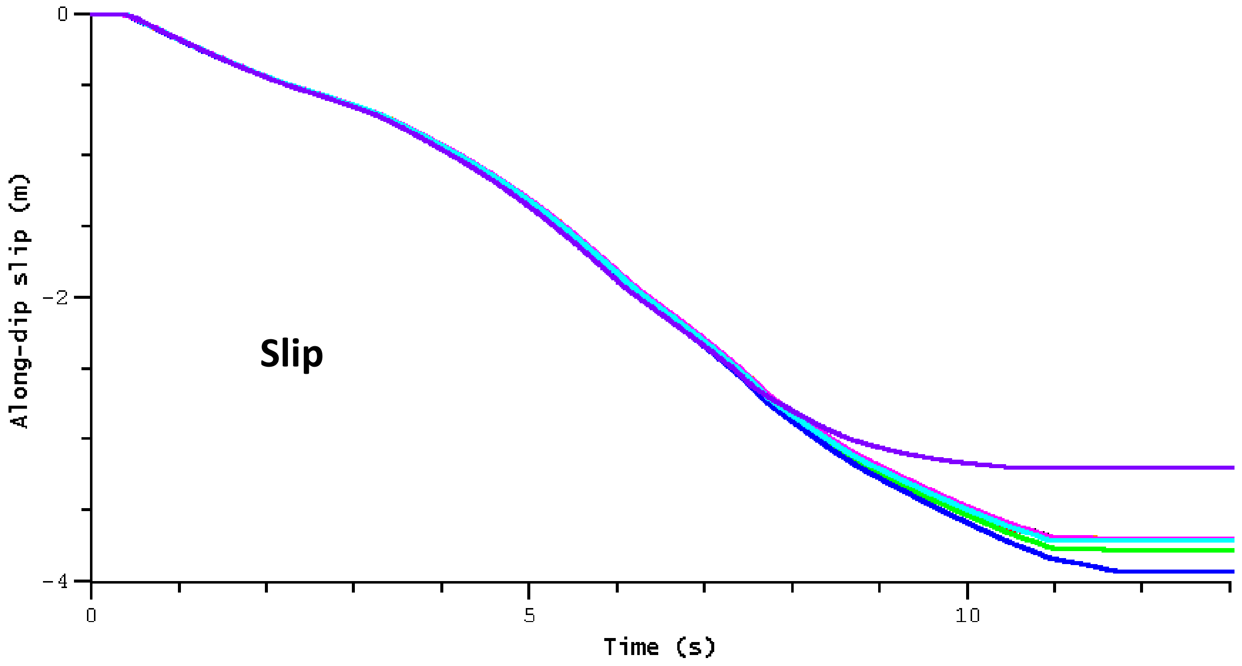


Metrics for slip rate

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
(1) barall		4.1	5.0	11.2	1.4	1.4	4.1	24.6
(2) dliu.2	4.1		5.4	12.5	3.9	3.9	3.5	23.4
(3) kutschera.2	5.0	5.4		9.7	4.8	4.8	3.9	26.6
(4) li.2	11.2	12.5	9.7		11.0	11.0	11.2	30.6
(5) ma	1.4	3.9	4.8	11.0		0.0	3.5	24.7
(6) wang	1.4	3.9	4.8	11.0	0.0		3.5	24.7
(7) wzhang	4.1	3.5	3.9	11.2	3.5	3.5		24.8
(8) yang	24.6	23.4	26.6	30.6	24.7	24.7	24.8	

Normalized RMS difference (percent)

0.3 – 93.9



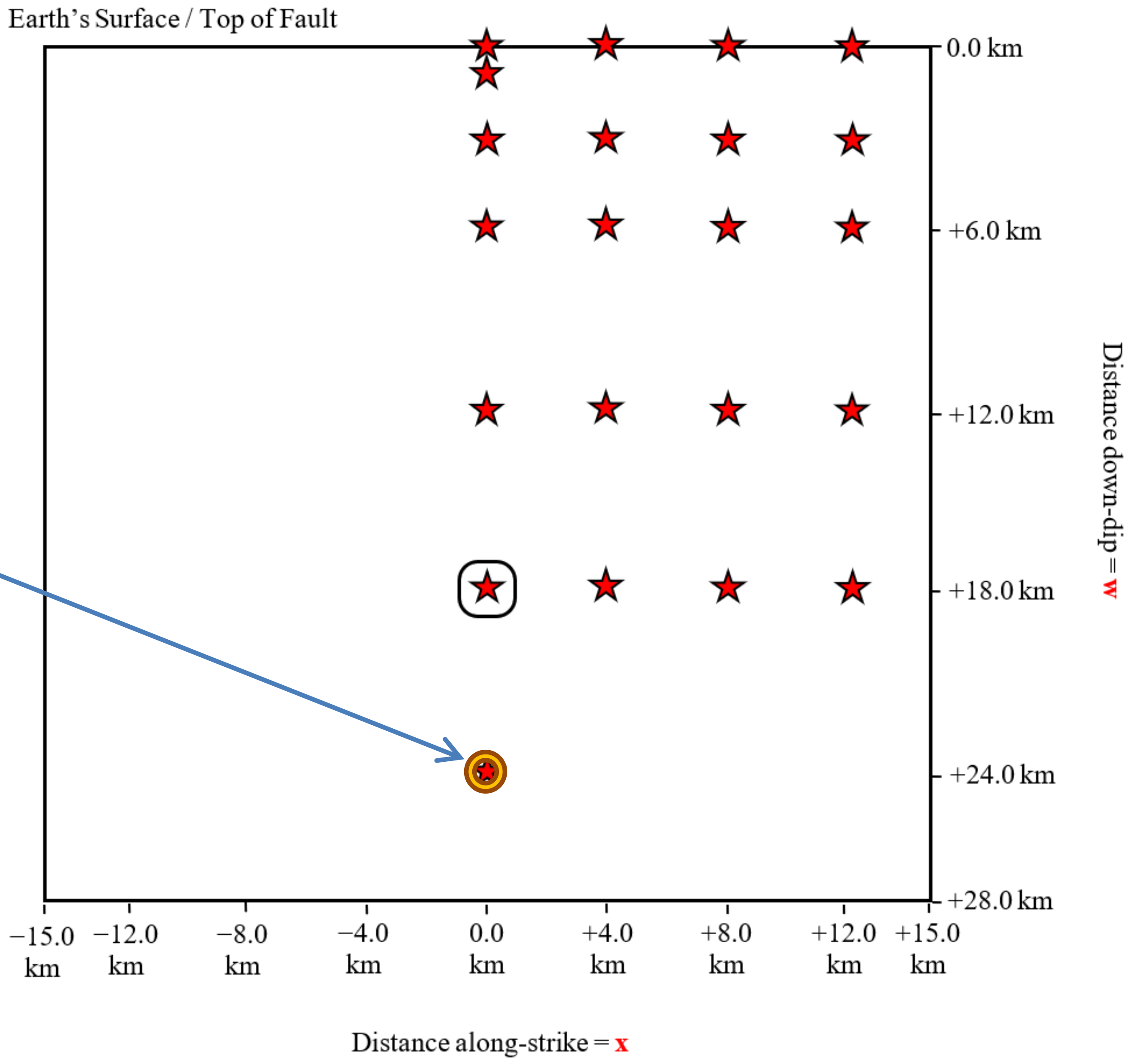
Slip rate and shear stress are low-pass filtered at 10 Hz

- barall (Michael Barall - FaultMod - 50 m)
- dliu.2 (EQdyna.v5.3.3.50m.dliu)
- kutschera.2 (Fabian Kutschera - DG - SeisSol v1.2.0 - fault 200 m - o4)
- li.2 (Duo Li - DG FE,h=200m, O4)
- ma (Shuo Ma - Finite Element - MAFE - 50 m on fault)
- wang (Yongfei Wang - Generalized Finite Difference - SORD)
- wzhang (Wenqiang Zhang - Mixed-Flux DG (200m~10km, O4))
- yang (Hongfeng Yang - Finite Element - PyLith)

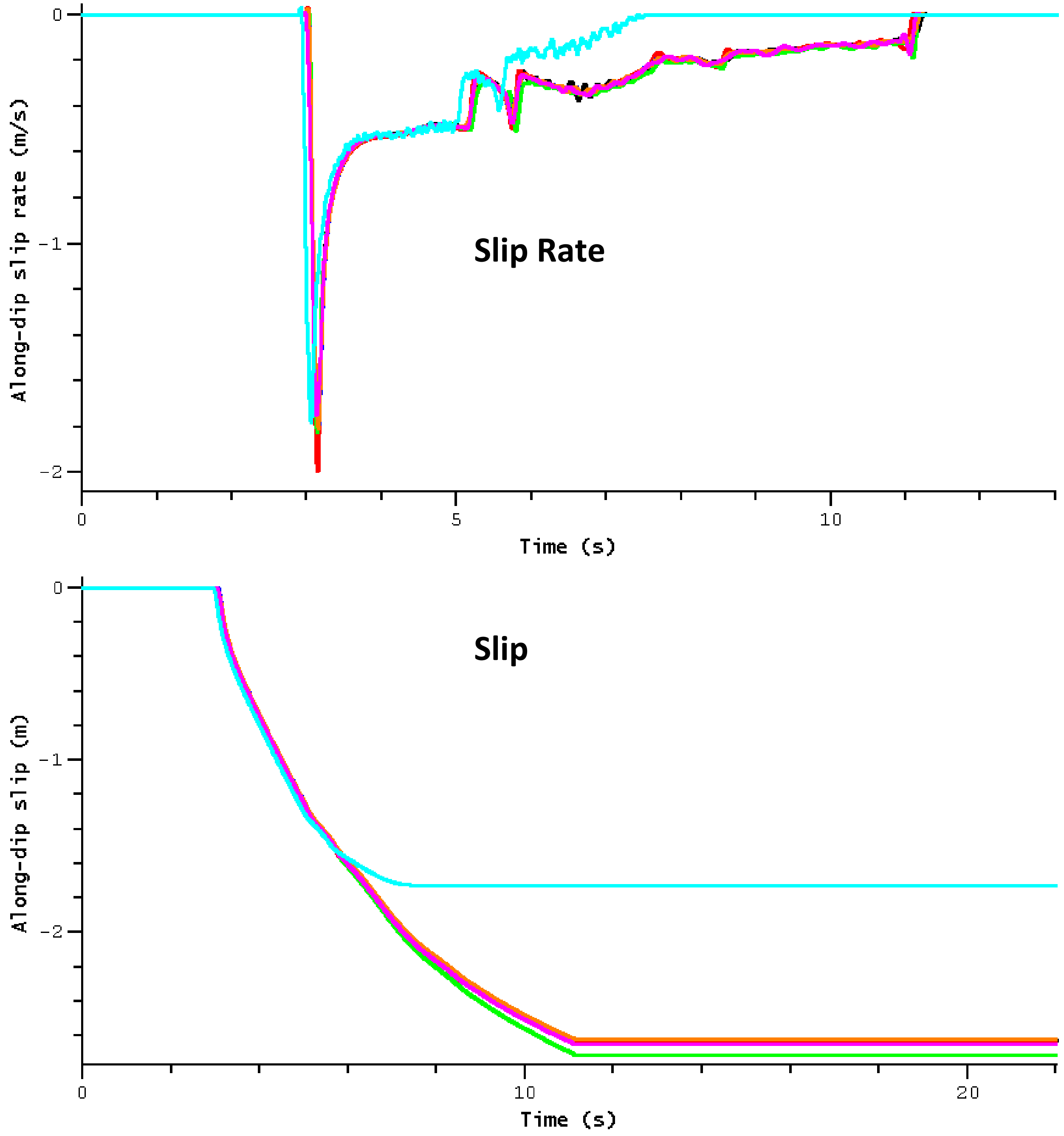
Distance along strike

Distance down-dip

faultst000dp240



At a dip angle of 15 degrees, the depth is about 1/4 of the distance down-dip.



TPV36 – On-Fault Station: faultst000dp240

Metrics for slip rate

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
(1) barall		4.3	7.3	3.6	3.6	4.9	36.9
(2) dliu.2	4.3		9.3	4.3	4.3	6.0	36.4
(3) kutschera.2	7.3	9.3		8.8	8.8	9.1	40.5
(4) ma	3.6	4.3	8.8		0.0	3.2	36.5
(5) wang	3.6	4.3	8.8	0.0		3.2	36.5
(6) wzhang	4.9	6.0	9.1	3.2	3.2		37.4
(7) yang	36.9	36.4	40.5	36.5	36.5	37.4	

Normalized RMS difference (percent)

0.3 — 93.9

Slip rate and shear stress are low-pass filtered at 10 Hz

- barall (Michael Barall - FaultMod - 50 m)
- dliu.2 (EQdyna.v5.3.3.50m.dliu)
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- ma (Shuo Ma - Finite Element - MAFE - 50 m on fault)
- wang (Yongfei Wang - Generalized Finite Difference - SORD)
- wzhang (Wenqiang Zhang - Mixed-Flux DG (200m~10km, O4))
- yang (Hongfeng Yang - Finite Element - PyLith)

Conclusions

We created two benchmarks with a 15-degree dipping thrust fault.

- TPV36 – Rupture reaches the Earth's surface.
- TPV37 – Rupture stops spontaneously before it reaches the Earth's surface.

8 modelers or groups successfully ran the benchmarks and submitted results.

7 modelers submitted surface deformation files.

- All have similar patterns of uplift and subsidence, which is important for tsunami generation.
- The majority of codes agree very well on the values of peak uplift and subsidence.

Contour plots from all the codes are similar.

For time series data, most of the codes produced results that agree well throughout the simulation.

- Some codes have differences from the other codes, indicating a possible opportunity for improvement.

Thank you to all the modelers and groups who submitted results! We can't do this without you!