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A static arrest criterion classifies some fault-spanning ruptures as arrested

Wenjie Lyu

School of Civil Engineering, China University of Mining and Technology, Xuzhou, China

WenjieLyu02@gmail.com

<https://orcid.org/0009-0009-3039-7727>

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Wenjie Lyu

School of Civil Engineering, China University of Mining and
Technology, Xuzhou, China

WenjieLyu02@gmail.com

ORCID 0009-0009-3039-7727

Abstract

A static arrest length and a fully dynamic rupture are compared, one rupture at a time, for 60 antiplane and 60 in-plane cases on one 120 km fault with linear slip weakening and one correlation length of the initial stress. The standard deviations were fixed before those ruptures were drawn. The comparison tests the rule, used to build earthquake populations, that a rupture stops where its static energy release rate falls below the fracture energy and that this rule decides which ruptures span the fault. In 22 of the 120 cases the two calculations disagreed on whether the rupture spanned the fault, and in all 22 the static criterion predicted arrest while the dynamic rupture spanned the fault. All 22 still spanned the fault when the spacing along strike was halved. Where both stopped, the dynamic length was longer in 41 of 42 antiplane cases and 38 of 40 in-plane cases, and the median ratio was 1.08 in each mode. The in-plane values depend on the grid across the fault: with half the nodes, the in-plane median ratio was 0.99 and seven of the twelve in-plane disagreements remained. Three-dimensional rupture and other slip-weakening distances were not tested.

1. Introduction

Sixty antiplane and sixty in-plane ruptures are calculated on one 120 km fault, and a static arrest length is compared with a fully dynamic rupture, one rupture at a time. The fault uses linear slip weakening and one correlation length of the initial stress. The standard deviations and the static lengths were fixed before the dynamic runs. Both modes are run because in-plane rupture can become supershear and antiplane rupture cannot.

A static comparison between energy release rate and fracture energy is used to decide where a rupture stops, both for the size distribution of earthquakes on a random stress field [McLaskey et al., 2026] and for the arrest area of induced earthquakes [Galis et al., 2017].

Ampuero et al. [2006] show that a semi-dynamic form of the comparison reproduces the change from a broad size distribution to events that span the fault, and

McLaskey et al. [2026] use the static form to build their populations. Galis et al. [2017] match three-dimensional dynamic arrest areas to the static estimate after multiplying the static area by two. A population is built by applying the static comparison to many ruptures. In the laboratory, a rupture passes a stress barrier that the static comparison would stop when the barrier causes a supershear transition, or when slip on one side of the barrier loads the other [Paglialunga et al., 2026].

Each of these uses the static balance at the rupture tip to decide where the rupture stops. The comparison above asks whether the fault-spanning class given by that balance agrees with the class of the dynamic rupture.

2. Method

The fault is 120 km long in a uniform elastic full space, and the ruptures are solved with `fdfault` [Daub, 2020]. The density is $\rho = 2.67 \text{ g cm}^{-3}$, the shear-wave speed is $v_s = 3.464 \text{ km s}^{-1}$, and the compressional-wave speed is $v_p = 6 \text{ km s}^{-1}$. Normal stress is 120 MPa, and the static and dynamic friction coefficients are 0.677 and 0.525, so the strength drop is 18.24 MPa. Friction is linear slip weakening with $D_c = 0.4 \text{ m}$, and the fracture energy is half the strength drop times D_c , $G_c = 3.648 \text{ MJ m}^{-2}$. The spacing along strike is 200 m, and the domain extends 28 km on each side of the fault, with absorbing outer boundaries. Antiplane runs use 71 nodes across each side, a spacing of 400 m. The in-plane lengths below use 141 nodes, so the spacing is 200 m in both directions, and the same in-plane stress was also run with 71 nodes. Section 3 also reports reruns at 100 m along strike for an earlier set of 30 antiplane ruptures, for the 60 antiplane ruptures of the main text, and for the twelve in-plane disagreements with four arrested in-plane ruptures chosen beforehand as controls. The cohesive-zone estimate μD_c divided by the strength drop is 703 m, about 3.5 intervals of the 200 m grid. The 703 m value is a static length from the parameters, not a width measured on the propagating rupture.

The initial shear stress is a zero-mean random field with the power spectrum of Ampuero et al. [2006], Hurst exponent 1, and a correlation length of five antiplane nucleation half-lengths. That half-length, from Uenishi and Rice [2003] as written by Ampuero et al. [2006], is 407 m, so the correlation length is 2.03 km. The standard deviation is 0.343, 0.393, or 0.443 times the strength drop, with twenty ruptures at each value in each mode. The middle value, 0.393, is the mean-field transition estimated for this fault length from Eqs. (15) and (18) of Ampuero et al. [2006] before any of these ruptures were run, and the other two values lie 0.05 below and above it. The hypocenter is the maximum of the field after smoothing with the nucleation filter of Ampuero et al. [2006], and draws whose maximum lay within 40 km of either fault end were discarded and redrawn. A uniform stress is then added so that the filtered peak equals the yield stress, and the field is symmetrized about the hypocenter where its mirror image lies on the fault. Rupture starts from 0.1824 MPa, 1 % of the strength drop, added within one nucleation half-length of the hypocenter. For in-plane rupture the filter, the uniform stress, the hypocenter, and the added stress patch use the in-plane nucleation half-length, 542 m, on the same random field as the corresponding antiplane rupture. An unchanged copy of the antiplane stress array would have left the in-plane filtered peak below the yield stress in 55 of the 60 fields.

The static length is computed before the dynamic run and is not changed afterward. A crack grows from one nucleation half-length on either side of the hypocenter,

and a tip advances by 100 m when its static stress intensity factor exceeds $K_c = \sqrt{2\mu G_c}$, stopping at the end of the fault. For in-plane rupture the threshold is $\sqrt{2\mu G_c/(1-\nu)}$ with $\nu = 0.25$, because the energy release rate carries the factor $1 - \nu$. The rupture is called fault-spanning when the crack is at least 108 km long. The crack growth above is the semi-dynamic arrest rule of Ampuero et al. [2006], applied at both tips because the stress is not symmetric near the ends of a finite fault. For a uniform stress drop $\Delta\tau = 5$ MPa on a crack of half-length $a = 10$ km, both tips reproduce $\Delta\tau\sqrt{\pi a}$. The dynamic length in the ratios below is the distance between the outermost nodes whose final slip is at least D_c . A dynamic rupture is called fault-spanning when the distance between the outermost nodes with positive rupture time is at least 108 km. Those two definitions, and the rule for calling a disagreement one-sided, were fixed before the 60 antiplane and 60 in-plane ruptures were drawn. Each rupture enters a sign test once, within its own mode. An antiplane and an in-plane rupture with the same standard deviation and draw share one random field, so the comparison between modes is paired. Table S1 in the Supporting Information lists every rupture.

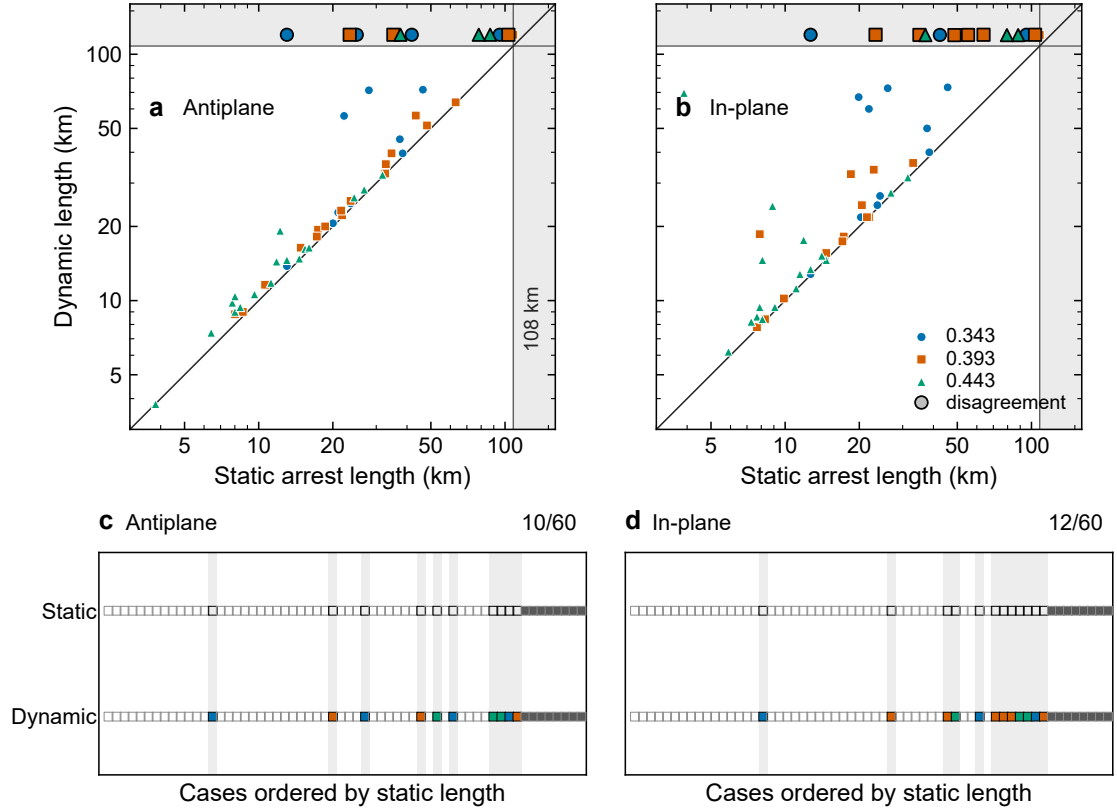


Figure 1: Dynamic length against the static arrest length for antiplane rupture (a) and in-plane rupture (b), and the fault-spanning class of the same ruptures (c, d). The dynamic length is the span on which the final slip exceeds the slip-weakening distance, and the diagonal is equal length. Both axes in (a) and (b) are logarithmic. Gray bands, and the line marked 108 km, are the fault-spanning class. A black edge marks a disagreement, in which the static criterion predicted arrest and the dynamic rupture spanned the fault. Colors and symbols are the standard deviation of the initial stress divided by the strength drop. In (c) and (d) the ruptures are ordered by increasing static length. The upper square is the static class and the lower square is the dynamic class: a filled square spanned the fault and an open square arrested. The in-plane lengths and classes are from the grid with 141 nodes across the fault.

3. Results

The rule for calling a disagreement one-sided was written after an exploratory set of 30 antiplane ruptures with the same friction and spectrum, ten at each standard deviation, whose hypocenters were not kept away from the fault ends. On that set the static criterion and the dynamic rupture agreed on fault-spanning status in 25 of 30 cases, and all five disagreements were static arrests that spanned the fault dynamically. The mean-field transition of Ampuero et al. [2006] had implied at least 8 fault-spanning ruptures of 10 at 0.343 times the strength drop; the dynamic calculation gave 6, and the static criterion, applied rupture by rupture, gave 3. The same 30 ruptures were rerun with 100 m spacing along strike. No rupture changed fault-spanning status, so the five disagreements remain, and the rupture-time span of each rupture changed by at most 0.4 km. The 120 ruptures below use new random fields, drawn after that rule was written, with hypocenters at least 40 km from both ends.

Figure 1 shows the dynamic length against the static length for all 120 ruptures, and the fault-spanning class of each rupture. Most points lie above the line of equal length, and dynamic ruptures that spanned the fault plot at or just below 120 km.

Antiplane rupture cannot become supershear. In antiplane rupture, 42 of 60 ruptures stopped in both calculations, the dynamic length was longer in 41 of those 42, and a one-sided sign test gives $p = 9.8 \times 10^{-12}$, with a median ratio of 1.08. Measured by rupture-time span instead, all 42 were longer, with a median ratio of 1.11. Ten of the 60 were arrested by the static criterion and spanned the fault in the dynamic calculation, and none was fault-spanning in the static calculation and arrested in the dynamic one. In nine of those ten, the front moved more slowly over the 3 km beyond the static end than over the 3 km before it. In four, the rupture time jumped by 2.5 to 10.2 s between neighboring nodes within 5 km of the static end. In all ten, no node within 10 km beyond the end ruptured before the node at the end. The semi-dynamic rule of Ampuero et al. [2006] uses the static stress intensity factor, so it does not include how the dynamic value varies about the static one after the front slows. At 0.343 times the strength drop, the static criterion let 7 of 20 ruptures span the fault and the dynamic calculation 11.

In-plane rupture can become supershear. In the in-plane set with 141 nodes across the fault, 40 of 60 ruptures stopped in both calculations, the dynamic length was longer in 38 of those 40 ($p = 7.5 \times 10^{-10}$), and the median ratio was 1.08, as in the antiplane set. By rupture-time span, all 40 were longer, with a median ratio of 1.16. Twelve were arrested by the static criterion and spanned the fault in the dynamic calculation, and none was fault-spanning in the static calculation and arrested in the dynamic one. At 0.343 times the strength drop the counts were 7 static and 10 dynamic. On the 39 fields where both calculations stopped in both modes, the in-plane ratio was the larger in 16 ($p = 0.90$). Each of the twelve in-plane disagreements contained a 5 km stretch of successive ruptured nodes whose length, divided by the difference in rupture time between its ends, exceeded the shear-wave speed, as did 15 of the other 48 in-plane ruptures. Rupture speed was not one of the comparisons fixed before the runs.

In both modes, all 22 disagreements reached at least 119.6 km on both definitions, past the 108 km mark used to call a rupture fault-spanning. They come from 13 of the 60 random fields, and nine fields gave a disagreement in both modes, so the 22 are not independent cases. The excess length is also present far from that mark: among ruptures whose static length was under 20 km, the dynamic length was longer in 21 of

22 antiplane cases (median ratio 1.10) and 24 of 25 in-plane cases (median ratio 1.06).

With 71 nodes across the fault, the in-plane median ratio was 0.99, and 21 of the 45 ruptures that stopped in both calculations were longer in the dynamic run. Raising the number of nodes across the fault from 71 to 141 changes five ruptures from arrested to fault-spanning, all five in that direction, while the median absolute change in the logarithm of the dynamic length is 0.066 (Fig. S2). The twelve in-plane disagreements were rerun with 100 m spacing along strike and 141 nodes across the fault, together with the four arrested in-plane ruptures with the longest dynamic length, chosen as controls before the runs. All twelve still spanned the fault, at least 119.8 km on both definitions, and none of the four controls did; their dynamic lengths changed by at most 0.2 % (Fig. S1). The 60 antiplane ruptures were rerun with 100 m spacing along strike and 71 nodes across the fault. All ten disagreements still spanned the fault, and no rupture of the 60 changed fault-spanning class.

4. Discussion

On this fault the static criterion and the dynamic rupture disagreed on fault-spanning class for 22 of 120 ruptures, all in the same direction: no rupture that the static criterion let span the fault arrested in the dynamic calculation. The direction agrees with Galis et al. [2017], who multiplied the static area by two to match a different set of three-dimensional ruptures. Where both calculations stopped on this fault, the median length ratio is 1.08. Ampuero et al. [2006] used the same semi-dynamic rule to reproduce the change in the shape of a population; here the rule is compared with the dynamic rupture one field at a time. Whether the in-plane disagreements involve the barrier-induced supershear transition seen in the laboratory [Paglialunga et al., 2026] was not tested.

The calculations cover one fault length, one slip-weakening distance, one correlation length, and two dimensions. The two modes use the same random draw. The in-plane nucleation length, the added stress, and the grid across the fault differ. The 200 m spacing along strike gives about 3.5 intervals across the 703 m cohesive-zone estimate, fewer than the five nodes that Day et al. [2005] required for their finite-difference method. The exploratory set, the 60 antiplane ruptures, and the twelve in-plane disagreements, with four controls, were refined to 100 m, about seven intervals, and none changed class; the other in-plane ruptures rest on the 200 m grid. The 400 m spacing across the fault in antiplane runs was not refined, although in in-plane runs halving that spacing changed the class of five ruptures. The in-plane count of 12 is the count with 141 nodes across the fault, and five of the twelve are fault-spanning only on that grid.

A constant correction was also fitted to the same 120 ruptures, so it describes these runs and does not predict new ones. The static threshold K_c was divided by factors from 1.00 to 1.60 in steps of 0.01. Agreement on fault-spanning class rose from 98 of 120 at 1.00 to 104 at 1.43 and stayed at 104 up to 1.60, the end of the range, with 16 disagreements left. Within that range, 1.46 gave the smallest median misfit in length, the tie rule set before the fit. Because $G_c \propto K_c^2$, dividing K_c by 1.46 lowers G_c from 75 to 35 J m⁻² in the population model of McLaskey et al. [2026]. Their published functions were run unchanged in Octave, with a standard deviation of 24 MPa, a white spectrum cut off at 5 m, and 4000 realizations at each mean stress from 0 to 3 MPa. Octave draws different random sequences from MATLAB, so every comparison uses the same seeds within Octave. The b value of their populations changed by at most 0.05, and the fraction of ruptures that never arrest changed by less than one percentage point. That

model is a one-sided crack starting at a free edge, with stress that is rough down to a few meters and often strongly negative. Only its fracture energy was changed, so the calculation is not a dynamic rupture on those fields.

5. Conclusions

On one 120 km fault in two dimensions, all 22 disagreements in fault-spanning class among the 120 ruptures were in the same direction: the static criterion predicted arrest and the dynamic rupture spanned the fault. All 22 still spanned the fault with 100 m spacing along strike. Where both calculations stopped, the dynamic length was longer in 41 of 42 antiplane and 38 of 40 in-plane cases, with a median ratio of 1.08 in each mode. The rupture-time span was longer in all 42 antiplane cases and all 40 in-plane cases. On this fault the static estimate of arrest length was slightly short in most cases, and a rupture stopped by that estimate could still span the fault. The in-plane count uses 141 nodes across the fault: with 71 nodes the median ratio is 0.99, and five of the twelve in-plane disagreements span the fault only on the finer grid. Whether dynamic ruptures on the stress fields of a population model change its size distribution was not calculated; the constant correction tried here changed that distribution little.

Code and data availability

The lengths and classes of all 120 ruptures are listed in Table S1 of the Supporting Information. The rupture outputs and the scripts that compute the lengths have not been released to a public archive. The solver is the public code cited above.

Author contributions

Wenjie Lyu: Conceptualization, Methodology, Software, Formal analysis, Investigation, Visualization, Writing – original draft, Writing – review & editing.

Competing interests

The author declares that there is no conflict of interest.

Acknowledgements

The author used AI-based tools for English language editing. No AI tool generated the calculations, the numerical results, or the figures. The author reviewed the text and takes responsibility for the final content.

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Supporting information for “A static arrest criterion classifies some fault-spanning ruptures as arrested”

Wenjie Lyu

Contents

Table S1 lists the 120 ruptures of the main text, one row per rupture. Figure S1 shows the two checks at 100 m spacing along strike. Figure S2 compares the in-plane dynamic lengths on the grids with 71 and 141 nodes across the fault.

Definitions used in the table

The static length is the length of the static crack when both tips have arrested, computed before the dynamic run. The static class is fault-spanning (S) when that crack is at least 108 km long, and arrested (A) otherwise. The dynamic length is the distance between the outermost nodes whose final slip is at least D_c . The rupture-time span is the distance between the outermost nodes with positive rupture time, and the dynamic class is fault-spanning when it is at least 108 km. The ratios and sign tests in the main text use the dynamic length. Each rupture enters a sign test once, within its own mode. The antiplane and in-plane ruptures with the same standard deviation and draw share one random field, so the comparison between modes is paired, and the two modes are not independent samples.

Figures

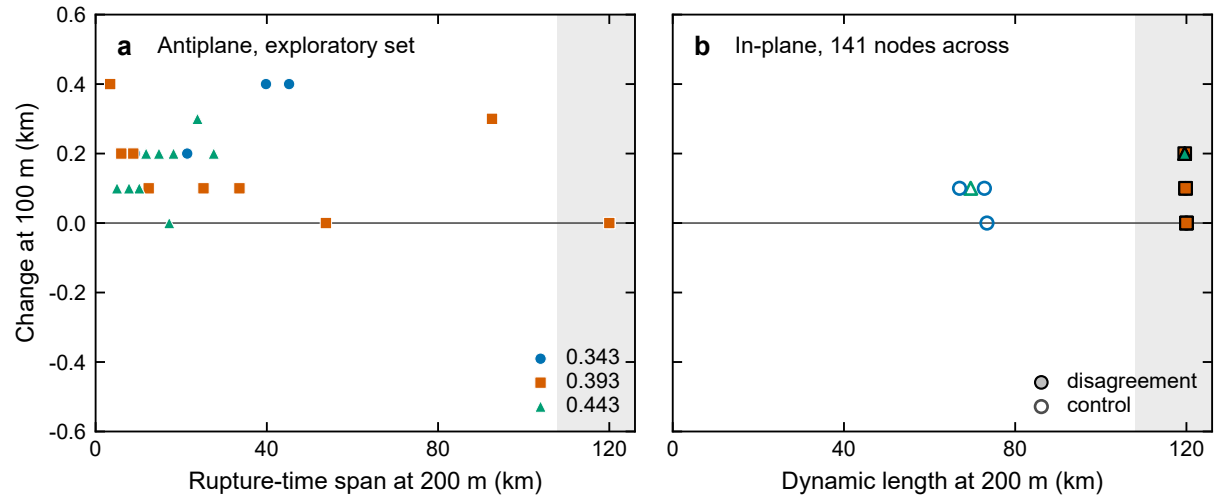


Figure S1: Change in length when the spacing along strike is reduced from 200 m to 100 m. (a) The exploratory set of 30 antiplane ruptures, which is not part of the 120 ruptures of the main text; the length is the rupture-time span. (b) The twelve in-plane disagreements (filled, black edge) and four arrested controls chosen before the runs (open), all with 141 nodes across the fault; the length is the dynamic length. The gray band is the fault-spanning class. Ruptures that spanned the fault on both grids plot at 120 km and overlap. No rupture in either panel changed class. The 60 antiplane ruptures of the main text were rerun at 100 m and none changed class; they are not shown here. The other in-plane ruptures were not rerun at 100 m.

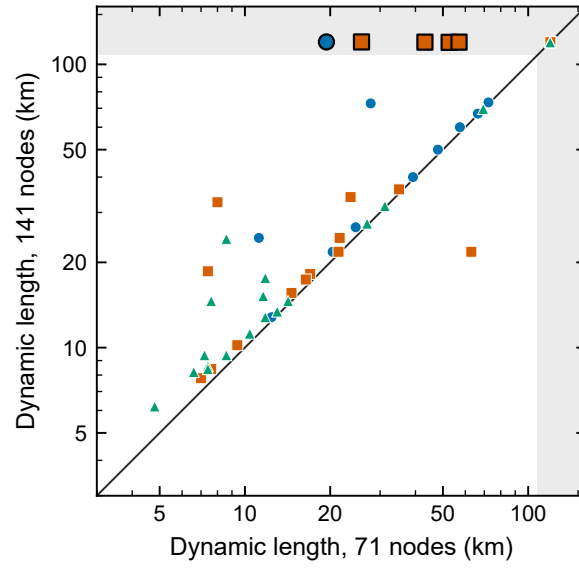


Figure S2: In-plane dynamic length with 71 and 141 nodes across the fault, for the same 60 stress fields. Both axes are logarithmic, the diagonal is equal length, and the gray bands are the fault-spanning class. A black edge marks the five ruptures that changed class between the two grids; all five changed from arrested to fault-spanning. Colors and symbols are as in Figure 1 of the main text.

Table

Table S1: The 120 ruptures of the main text. s.d. is the standard deviation of the initial stress divided by the strength drop. Draw numbers the twenty random fields at each standard deviation; the same number in the two modes is the same random field. Each field comes from the NumPy generator seeded with (20261022, s.d. in thousandths, draw, k), where $k = 0, 1, 2, \dots$ and the first k whose hypocenter lies at least 40 km from both ends is used. Lengths and the hypocenter position along the fault are in kilometers. A is arrested and S is fault-spanning; an asterisk marks a disagreement. Y marks the ruptures rerun at 100 m along strike. In-plane values are from the grid with 141 nodes across the fault.

Mode	s.d.	Draw	Hypocenter	Static	Class	Dynamic	Rupture time	Class	100 m
Antiplane	0.343	0	50.2	25.0	A	120.0	120.0	S*	Y
Antiplane	0.343	1	71.0	13.0	A	120.0	120.0	S*	Y
Antiplane	0.343	2	42.9	20.0	A	20.6	21.0	A	Y
Antiplane	0.343	3	74.0	108.1	S	120.0	120.0	S	Y
Antiplane	0.343	4	61.2	41.8	A	120.0	120.0	S*	Y
Antiplane	0.343	5	71.1	46.4	A	71.8	72.2	A	Y
Antiplane	0.343	6	60.6	37.4	A	45.2	46.0	A	Y
Antiplane	0.343	7	44.4	95.0	A	120.0	120.0	S*	Y
Antiplane	0.343	8	48.9	28.0	A	71.4	71.8	A	Y
Antiplane	0.343	9	49.9	13.0	A	13.8	14.2	A	Y
Antiplane	0.343	10	53.6	22.2	A	56.2	56.8	A	Y
Antiplane	0.343	11	56.9	21.0	A	22.8	23.2	A	Y
Antiplane	0.343	12	74.2	108.1	S	120.0	120.0	S	Y
Antiplane	0.343	13	74.9	108.1	S	120.0	120.0	S	Y
Antiplane	0.343	14	61.0	108.0	S	120.0	120.0	S	Y
Antiplane	0.343	15	67.4	38.4	A	39.6	40.0	A	Y
Antiplane	0.343	16	49.8	108.0	S	120.0	120.0	S	Y
Antiplane	0.343	17	47.4	23.6	A	24.8	25.2	A	Y
Antiplane	0.343	18	42.8	108.0	S	120.0	120.0	S	Y
Antiplane	0.343	19	62.5	108.0	S	120.0	120.0	S	Y
Antiplane	0.393	0	57.5	34.6	A	39.6	40.2	A	Y
Antiplane	0.393	1	67.6	10.6	A	11.6	12.0	A	Y
Antiplane	0.393	2	42.6	32.6	A	32.8	33.2	A	Y
Antiplane	0.393	3	52.2	8.0	A	8.8	9.2	A	Y
Antiplane	0.393	4	53.1	17.4	A	19.4	20.2	A	Y
Antiplane	0.393	5	73.5	23.4	A	120.0	120.0	S*	Y
Antiplane	0.393	6	54.9	17.2	A	18.2	18.6	A	Y
Antiplane	0.393	7	58.7	48.2	A	51.4	51.8	A	Y
Antiplane	0.393	8	58.9	23.6	A	25.4	25.8	A	Y
Antiplane	0.393	9	42.9	21.8	A	22.2	22.2	A	Y
Antiplane	0.393	10	48.7	32.8	A	35.8	36.2	A	Y
Antiplane	0.393	11	42.5	18.6	A	20.0	20.8	A	Y
Antiplane	0.393	12	59.9	63.0	A	63.8	64.2	A	Y
Antiplane	0.393	13	73.6	103.2	A	120.0	120.0	S*	Y
Antiplane	0.393	14	58.9	8.6	A	9.0	9.4	A	Y
Antiplane	0.393	15	54.0	43.4	A	56.4	56.8	A	Y
Antiplane	0.393	16	46.1	21.6	A	23.2	61.0	A	Y
Antiplane	0.393	17	46.0	35.2	A	120.0	120.0	S*	Y
Antiplane	0.393	18	43.8	108.0	S	120.0	120.0	S	Y
Antiplane	0.393	19	44.3	14.8	A	16.4	17.0	A	Y
Antiplane	0.443	0	76.1	24.4	A	26.2	26.8	A	Y
Antiplane	0.443	1	57.6	31.8	A	32.4	32.8	A	Y

Mode	s.d.	Draw	Hypocenter	Static	Class	Dynamic	Rupture time	Class	100 m
Antiplane	0.443	2	69.1	14.6	A	14.8	15.4	A	Y
Antiplane	0.443	3	65.1	7.8	A	9.8	10.6	A	Y
Antiplane	0.443	4	42.8	15.4	A	16.2	16.8	A	Y
Antiplane	0.443	5	58.3	12.2	A	19.2	19.8	A	Y
Antiplane	0.443	6	50.4	8.0	A	10.4	10.8	A	Y
Antiplane	0.443	7	76.1	6.4	A	7.4	7.8	A	Y
Antiplane	0.443	8	55.1	26.8	A	28.2	28.6	A	Y
Antiplane	0.443	9	76.1	37.6	A	120.0	120.0	S*	Y
Antiplane	0.443	10	42.6	11.8	A	14.4	15.2	A	Y
Antiplane	0.443	11	68.8	9.6	A	10.6	11.0	A	Y
Antiplane	0.443	12	72.1	87.0	A	120.0	120.0	S*	Y
Antiplane	0.443	13	72.7	78.2	A	120.0	120.0	S*	Y
Antiplane	0.443	14	72.7	13.0	A	14.6	15.0	A	Y
Antiplane	0.443	15	79.2	16.0	A	16.4	16.8	A	Y
Antiplane	0.443	16	62.7	8.0	A	9.0	9.6	A	Y
Antiplane	0.443	17	40.9	11.2	A	11.8	12.2	A	Y
Antiplane	0.443	18	67.9	3.8	A	3.8	4.2	A	Y
Antiplane	0.443	19	53.1	8.4	A	9.4	10.0	A	Y
In-plane	0.343	0	50.1	24.3	A	26.6	27.4	A	
In-plane	0.343	1	71.0	12.7	A	120.0	120.0	S*	Y
In-plane	0.343	2	42.8	19.9	A	67.0	67.8	A	Y
In-plane	0.343	3	73.8	108.0	S	120.0	120.0	S	
In-plane	0.343	4	61.2	42.5	A	119.8	119.8	S*	Y
In-plane	0.343	5	71.1	45.7	A	73.4	74.2	A	Y
In-plane	0.343	6	60.6	37.7	A	50.0	50.8	A	
In-plane	0.343	7	44.4	95.3	A	120.0	120.0	S*	Y
In-plane	0.343	8	49.1	26.1	A	72.8	73.6	A	Y
In-plane	0.343	9	50.0	12.7	A	12.8	13.6	A	
In-plane	0.343	10	53.5	21.9	A	60.0	60.8	A	
In-plane	0.343	11	56.8	20.3	A	21.8	22.6	A	
In-plane	0.343	12	74.2	108.0	S	120.0	120.0	S	
In-plane	0.343	13	75.1	108.1	S	120.0	120.0	S	
In-plane	0.343	14	61.0	108.1	S	120.0	120.0	S	
In-plane	0.343	15	67.4	38.5	A	40.0	40.8	A	
In-plane	0.343	16	49.9	108.1	S	120.0	120.0	S	
In-plane	0.343	17	47.4	23.7	A	24.4	25.2	A	
In-plane	0.343	18	42.7	108.1	S	120.0	120.0	S	
In-plane	0.343	19	62.5	108.1	S	120.0	120.0	S	
In-plane	0.393	0	53.0	22.9	A	34.0	34.8	A	
In-plane	0.393	1	67.5	9.9	A	10.2	11.2	A	
In-plane	0.393	2	42.7	18.5	A	32.6	33.0	A	
In-plane	0.393	3	52.3	7.7	A	7.8	8.6	A	
In-plane	0.393	4	53.1	17.3	A	18.2	19.0	A	
In-plane	0.393	5	73.5	23.3	A	120.0	120.0	S*	Y
In-plane	0.393	6	54.9	17.1	A	17.4	18.2	A	
In-plane	0.393	7	58.7	48.7	A	119.6	119.6	S*	Y
In-plane	0.393	8	58.8	20.5	A	24.4	25.2	A	
In-plane	0.393	9	42.8	21.9	A	21.8	22.4	A	
In-plane	0.393	10	48.7	33.1	A	36.2	37.0	A	
In-plane	0.393	11	42.5	7.9	A	18.6	19.4	A	

Mode	s.d.	Draw	Hypocenter	Static	Class	Dynamic	Rupture time	Class	100 m
In-plane	0.393	12	60.0	63.9	A	120.0	120.0	S*	Y
In-plane	0.393	13	73.5	103.4	A	120.0	120.0	S*	Y
In-plane	0.393	14	59.0	8.3	A	8.4	9.0	A	
In-plane	0.393	15	54.1	55.3	A	119.8	119.8	S*	Y
In-plane	0.393	16	46.2	21.5	A	21.8	60.4	A	
In-plane	0.393	17	46.1	35.1	A	119.8	119.8	S*	Y
In-plane	0.393	18	43.7	108.1	S	119.8	119.8	S	
In-plane	0.393	19	44.4	14.7	A	15.6	16.4	A	
In-plane	0.443	0	76.1	8.9	A	24.2	25.0	A	
In-plane	0.443	1	57.5	31.5	A	31.6	32.2	A	
In-plane	0.443	2	69.1	14.7	A	14.6	15.4	A	
In-plane	0.443	3	65.1	7.7	A	8.6	9.6	A	
In-plane	0.443	4	42.8	14.1	A	15.2	16.0	A	
In-plane	0.443	5	58.3	11.9	A	17.6	18.4	A	
In-plane	0.443	6	50.4	7.9	A	9.4	10.4	A	
In-plane	0.443	7	76.1	5.9	A	6.2	7.0	A	
In-plane	0.443	8	55.1	26.9	A	27.4	28.2	A	
In-plane	0.443	9	76.1	37.1	A	119.6	119.6	S*	Y
In-plane	0.443	10	42.7	11.5	A	12.8	13.6	A	
In-plane	0.443	11	68.8	9.1	A	9.4	10.2	A	
In-plane	0.443	12	72.1	88.3	A	119.6	119.6	S*	Y
In-plane	0.443	13	72.7	79.5	A	119.6	119.6	S*	Y
In-plane	0.443	14	72.7	12.7	A	13.4	14.2	A	
In-plane	0.443	15	79.1	8.1	A	14.6	15.4	A	
In-plane	0.443	16	62.6	7.3	A	8.2	9.0	A	
In-plane	0.443	17	41.0	11.1	A	11.2	12.0	A	
In-plane	0.443	18	67.9	3.9	A	69.6	70.0	A	Y
In-plane	0.443	19	53.2	8.1	A	8.4	9.6	A	