Supplementary text

S1. Guide to subduction-zone supplementary figures

For each subduction zone, we provide a standardized set of supplementary figures documenting the raw data, event selection, regime classification, comparison with the analytic model, and independent b-value-based stress-ratio estimates. The figure sequence is designed to guide the reader from observations to model comparison: maps show the regional tectonic setting and earthquake distributions; cross-sections show how selected earthquakes relate to the Slab2 interface; Rβ-Rα diagrams show regime classification and effective R estimates; obliquity–dip plots compare observed slip directions with theoretical predictions; and b-value panels provide an independent estimate of thrust-to–strike-slip stress ratios where event counts are sufficient.

To avoid repeating the same information for each subduction zone, we first provide the full caption description for each figure type below. In the individual subduction-zone sections, each figure is then accompanied only by a short-form caption giving the figure title and name of the subduction.

S1.1 Full caption descriptions for repeated figure types

Figure SX.a: Tectonic setting and map-view event distribution

This figure shows the regional tectonic setting and map-view distribution of earthquakes for each subduction zone. The upper map shows bathymetry, slab depth contours, arc volcanoes, major upper-plate faults, plate convergence vectors, and GCMT focal mechanisms. Interface thrust earthquakes (black) and upper-plate strike-slip earthquakes (red) are distinguished. The lower map shows the same region but colors interface thrust earthquakes by their regime classification in Rβ-Rα space. Green symbols denote partitioned events, orange symbols denote non-partitioned events, and red symbols denote anomalous events. Symbol size scales with earthquake magnitude.

Figure SX.b: Cross-sectional distribution of seismicity relative to Slab2

This figure shows map-view and trench-normal cross-sectional distributions of earthquakes relative to the Slab2 interface. Earthquakes are projected onto trench-normal profiles within along-strike equally spaced windows (yellow dashed boxes). Cross-sectional view perpendicular to the trench showing the depth distribution of earthquakes relative to the Slab2 interface. Interface thrust earthquakes (black rectangles with green outlines) are expected to cluster near the Slab2 interface, whereas upper-plate strike-slip earthquakes (red circles with green outlines) are expected to occur primarily above the slab. These plots provide an independent check on the event-classification workflow and support the assumptions of the simple analytic model setup of megathrust thrusting and upper-plate strike-slip deformation as major fault systems accommodating plate motion. Averaged across-profile locations of tectonic features like arc volcanoes and faults are annotated as well.

Figure SX.c: Regime classification in Rβ-Rα space

This figure shows the regime diagram for each subduction zone (Methods: M1.6 and M2.6). Each earthquake is plotted according to its convergence-obliquity ratio Rβ and slip-obliquity ratio Rα. Events above the 1:1 line are classified as partitioned (green) because earthquake slip obliquity is lower than convergence obliquity. Events near the 1:1 line are classified as non-partitioned (orange), and events below the 1:1 line are classified as anomalous (red). The optimal count-based effective ratio R# (blue dot and two lines), the optimal moment-weighted ratio RM (purple rectangle and two dashed lines), and the R# interval (blue shaded region bounded by two cyan diamonds) that captures 90% of partitioned events are annotated in the main figure. An upper-right inset is for the grid-search results for finding the optimal R*. It shows the fraction of event count and cumulative seismic moment relative to all partitioned events as a function of candidate R. These quantities summarize population-level behavior and are not interpreted as physical strength ratios for individual events.

Figure SX.d: Obliquity–dip comparison with analytic predictions

This figure presents pairs of earthquake slip obliquity α and convergence obliquity β as functions of local slab dip. Note that here includes all R#90% events [90% of all partitioned events]. Theoretical curves show the dip-dependent obliquity limit (eq. S4) and optimal slip-obliquity prediction for the best-fit R# (a_0 eq.S7 in bold grey dashed lines) and, where shown, the 90% R# interval is plotted with blue and cyan dashed lines. P2 events are highlighted as they satisfy the model-consistent partitioning condition relative to the optimal R#. Histograms summarize the distributions of α and β. These plots test whether megathrust slip obliquity is systematically lower than convergence obliquity and whether the observed separation follows the predicted dip dependence.

Figure SX.e: independent stress-ratio estimates from b-values

This figure provides an independent comparison between inferred population-level stress ratios R* under the context of the analytic model and b-value-based stress-ratio estimates Rb. Separate Gutenberg–Richter analyses are performed for interface thrust earthquakes and upper-plate strike-slip earthquakes. Panels show b-value estimates as functions of completeness magnitude Mc (A1,A2), cumulative frequency-magnitude distributions (B), and the resulting thrust-to-strike-slip stress ratio Rb with uncertainty (C) as well as earthquake depth distribution for fault area ratio (bottom panel). Rb estimates are used as first-order statistical proxies for relative stress levels and are compared with R# only as a consistency check. “Warning” indicates computed but weakly constrained Rb estimates due to low event counts or uncertain Mc.

1-alu: Aleutian

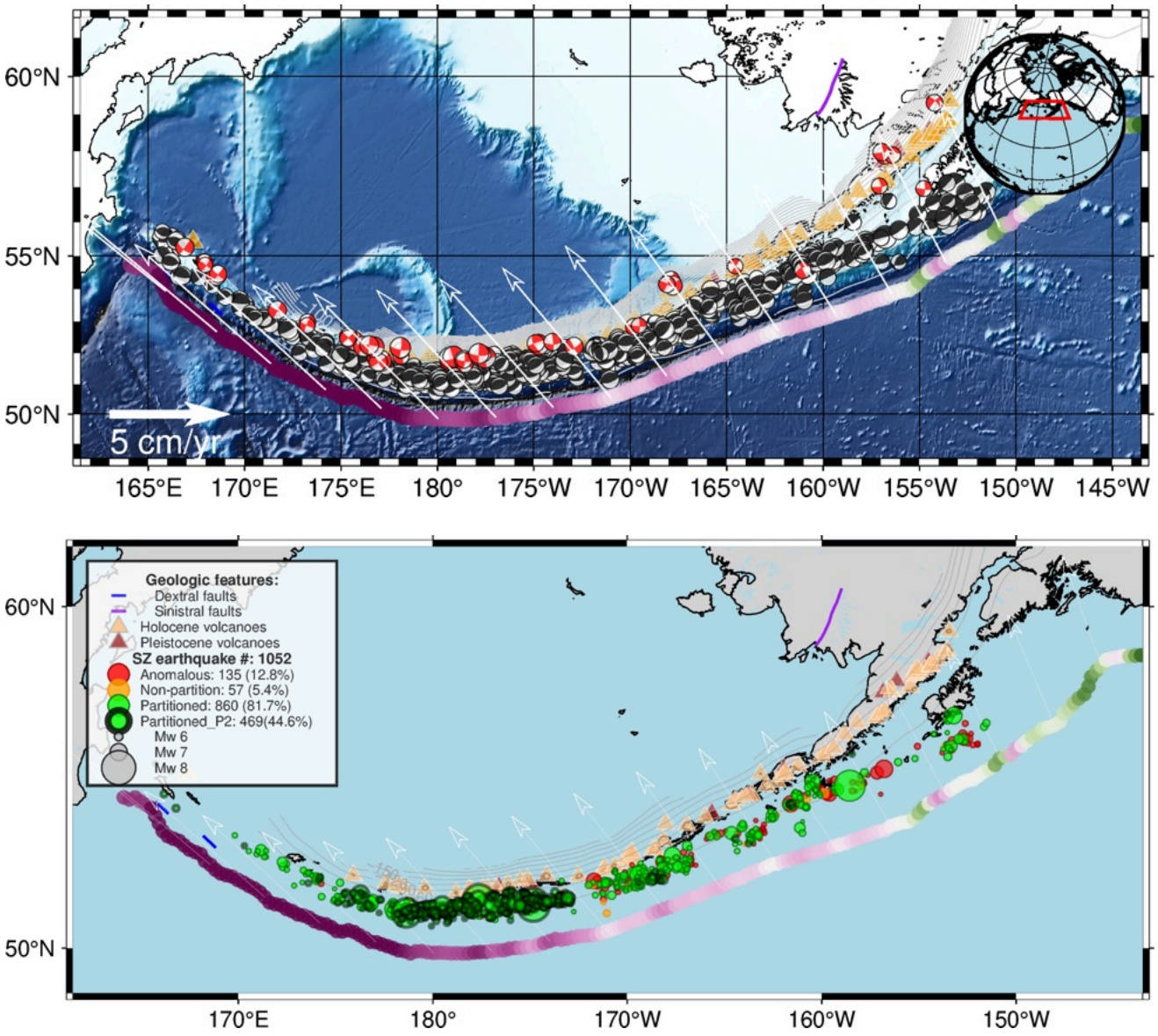


Fig. S-alu-a. Aleutian tectonic setting and earthquake distribution.

Regional map and regime-colored earthquake distribution for the Aleutian subduction zone. See Figure SX.a description for plotted quantities and symbol definitions.

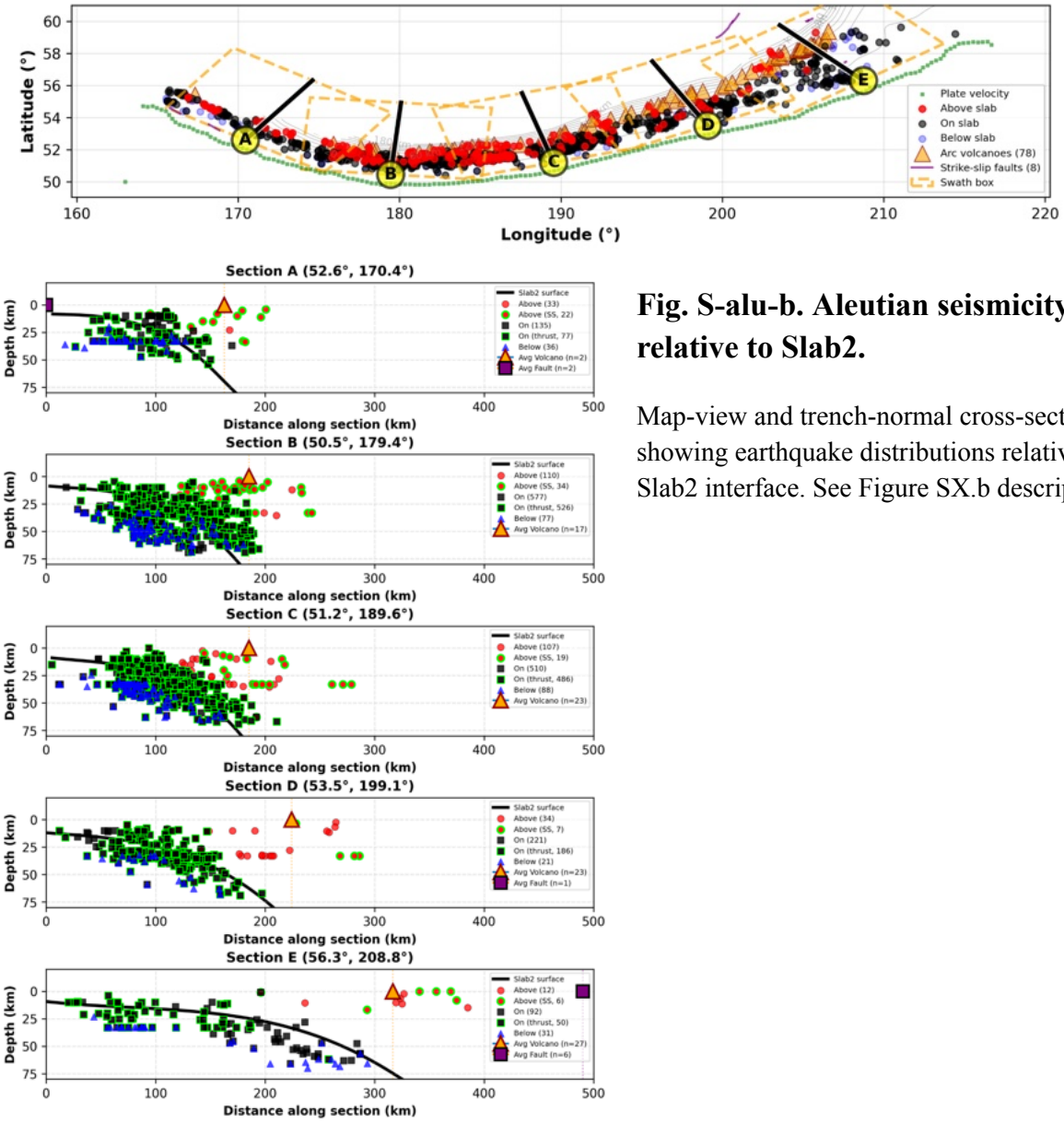


Fig. S-alu-b. Aleutian seismicity relative to Slab2.

Map-view and trench-normal cross-sections showing earthquake distributions relative to the Slab2 interface. See Figure SX.b description.

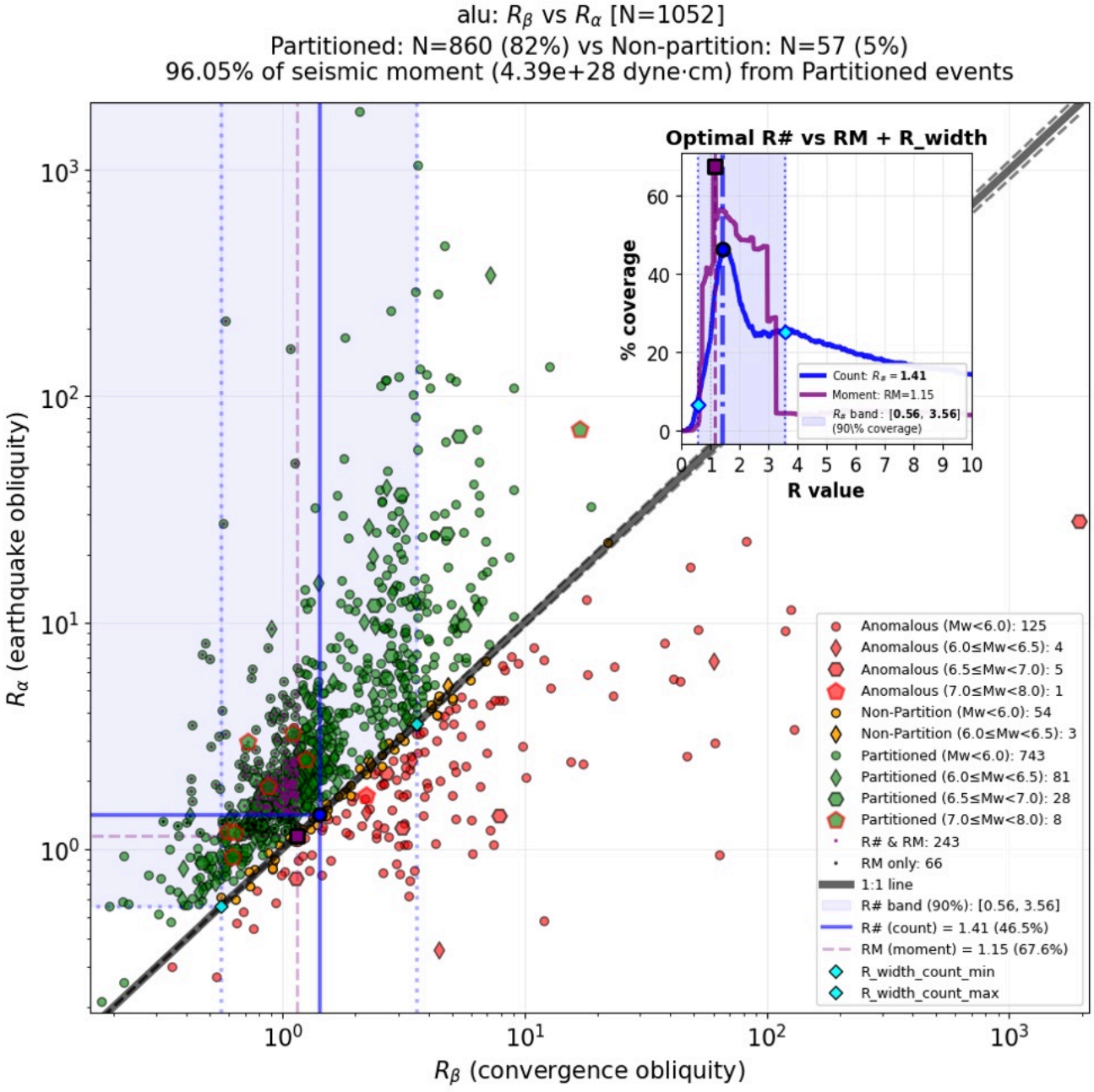


Fig. S-alu-c. Aleutian regime classification in Rβ-Rα space.

Normalized regime diagram showing partitioned, non-partitioned, and anomalous events, with R#, R_M, and R#90% interval. See Figure SX.c description.

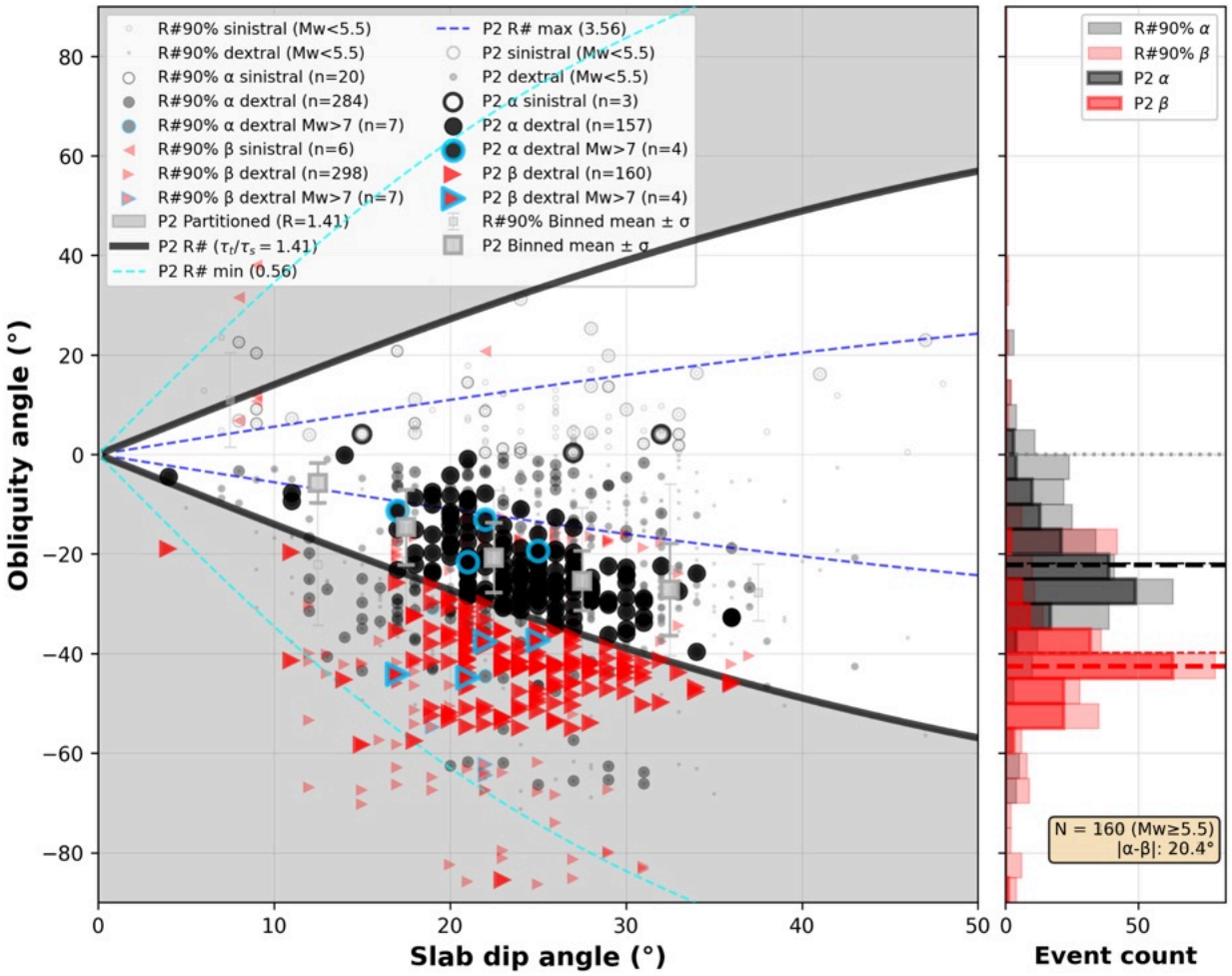


Fig. S-alu-d. Aleutian obliquity–dip comparison.

Earthquake slip obliquity and convergence obliquity plotted against slab dip, compared with analytic predictions. See Figure SX.d description.

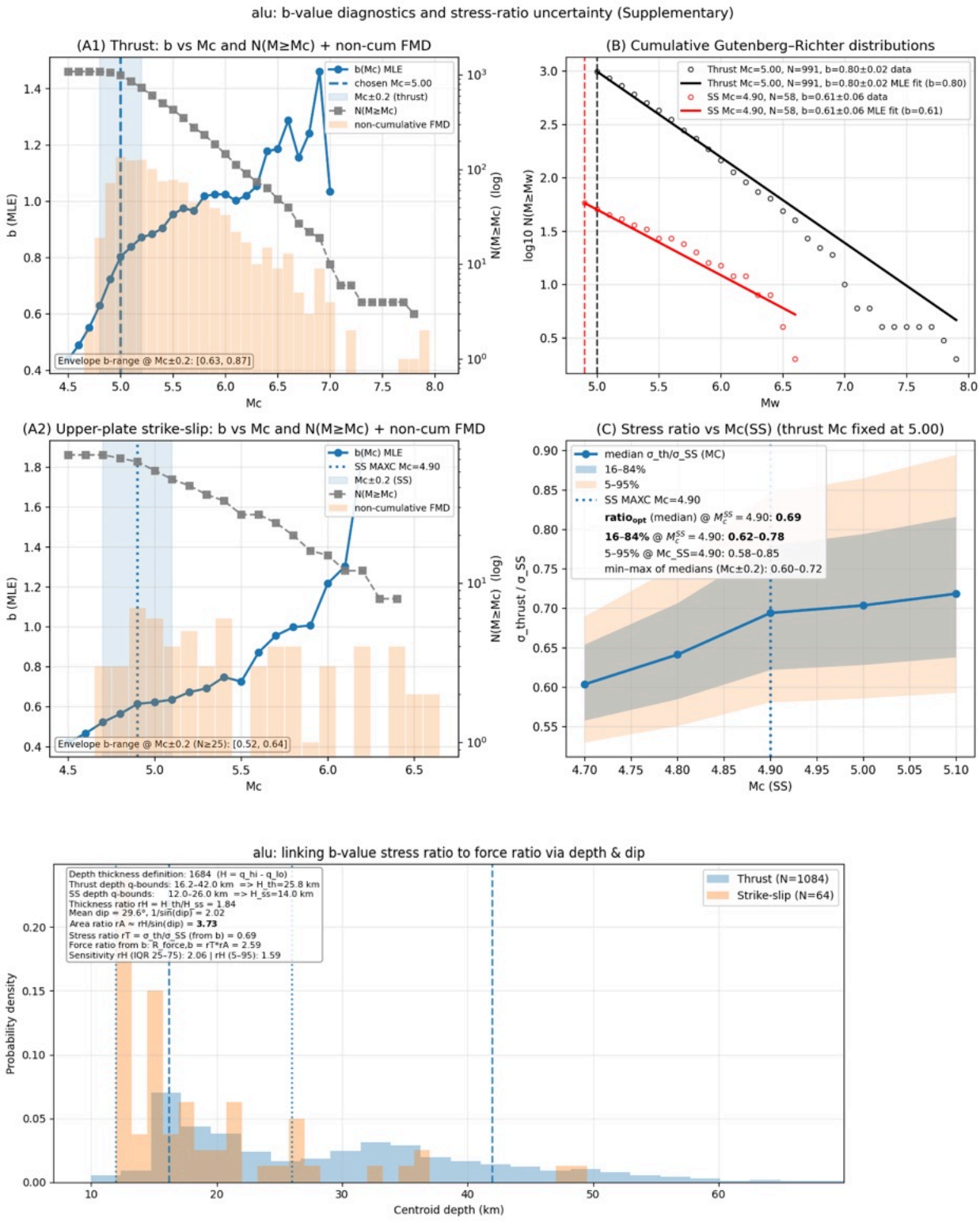


Fig. S-alu-e. Aleutian b-value stress-ratio estimate. b-value and thrust-to–strike-slip stress-ratio estimates for the Aleutian subduction zone. See Figure SX.e description.

2-cam: Central America

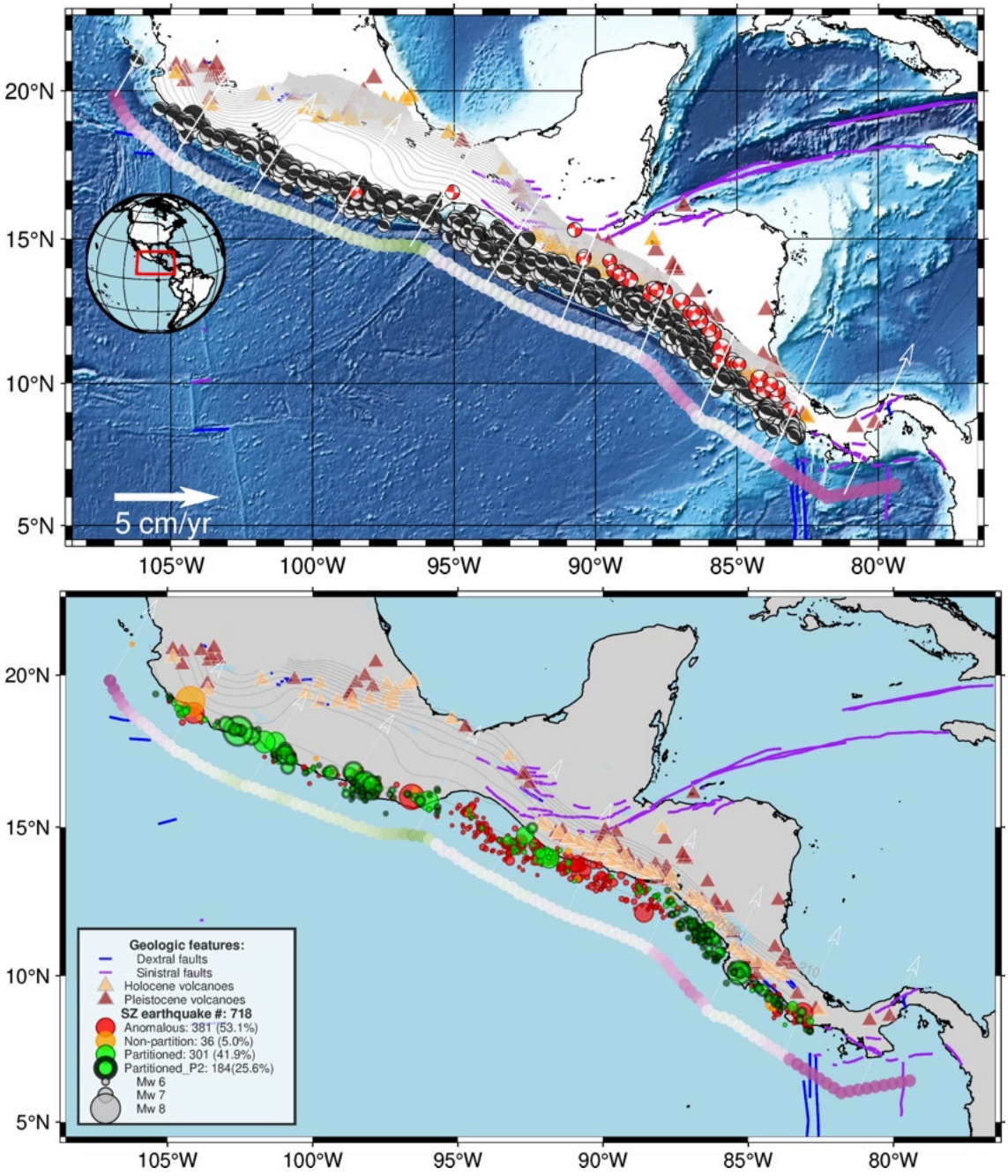


Fig. S-cam-a. Central America tectonic setting and earthquake distribution.

Regional map and regime-colored earthquake distribution for the Central America subduction zone. See Figure SX.a description for plotted quantities and symbol definitions.

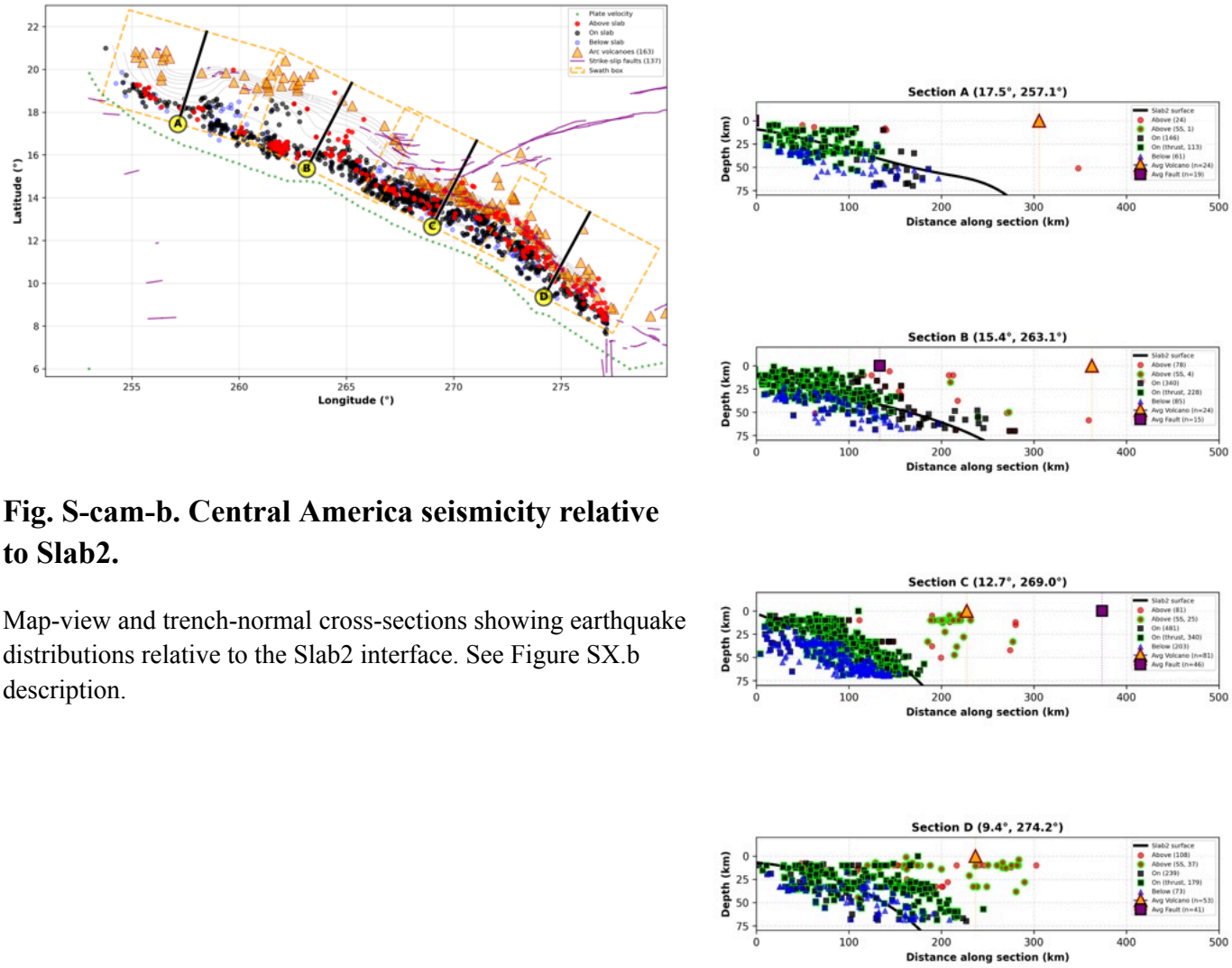


Fig. S-cam-b. Central America seismicity relative to Slab2.

Map-view and trench-normal cross-sections showing earthquake distributions relative to the Slab2 interface. See Figure SX.b description.

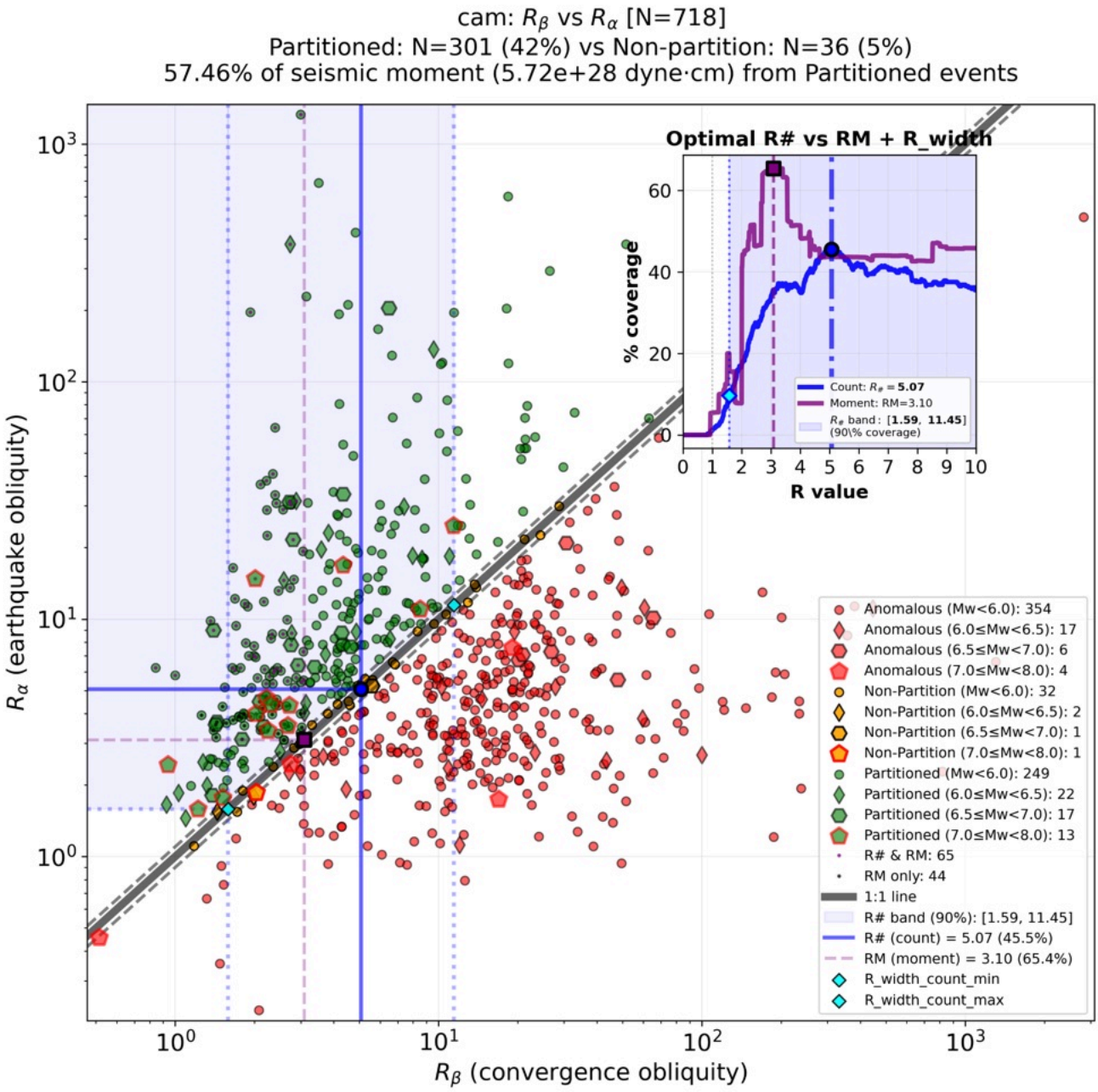


Fig. S-cam-c. Central America regime classification in Rβ-Rα space.

Normalized regime diagram showing partitioned, non-partitioned, and anomalous events, with R#, R_M, and R#90% interval. See Figure SX.c description.

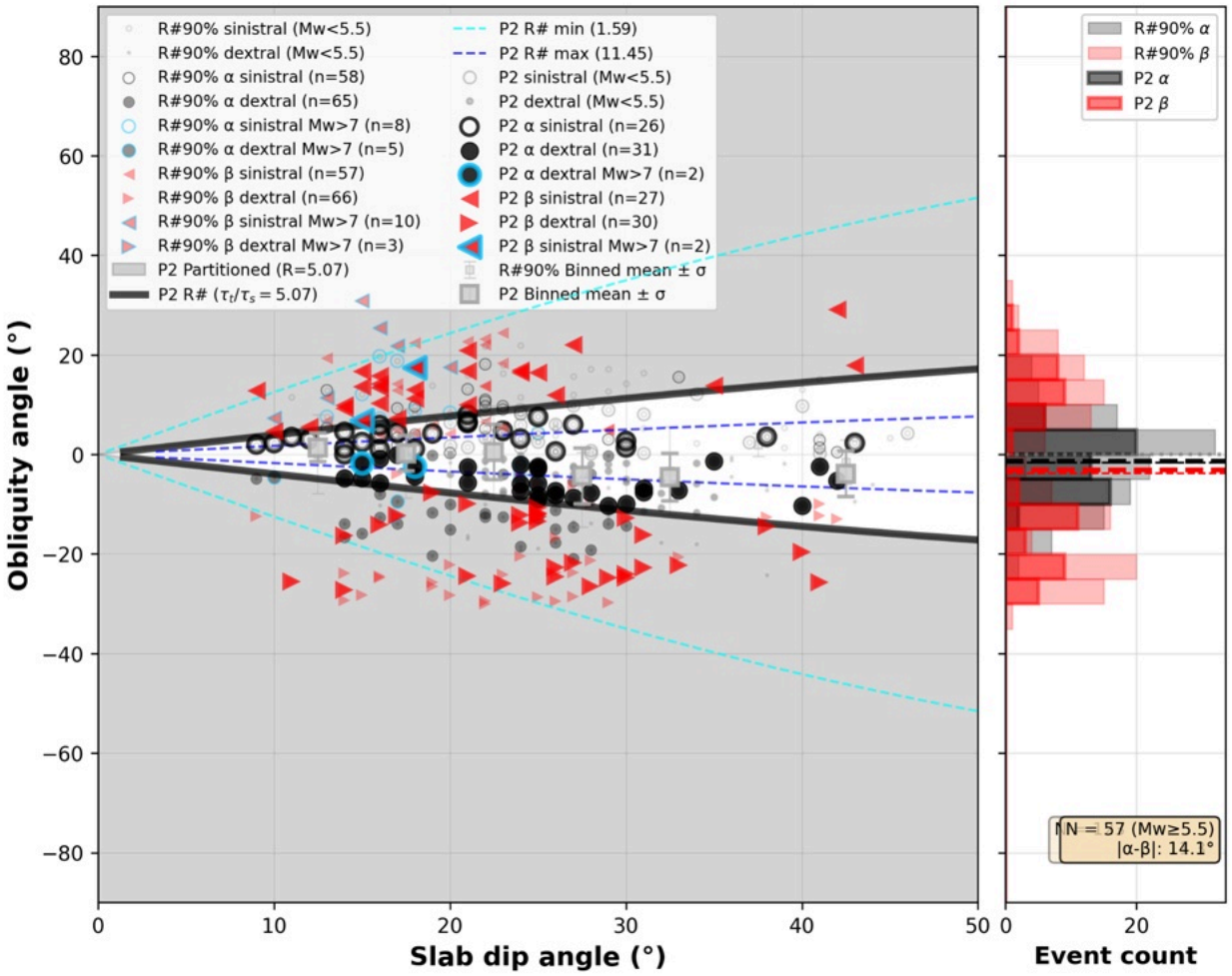


Fig. S-cam-d. Central America obliquity–dip comparison.

Earthquake slip obliquity and convergence obliquity plotted against slab dip, compared with analytic predictions. See Figure SX.d description.

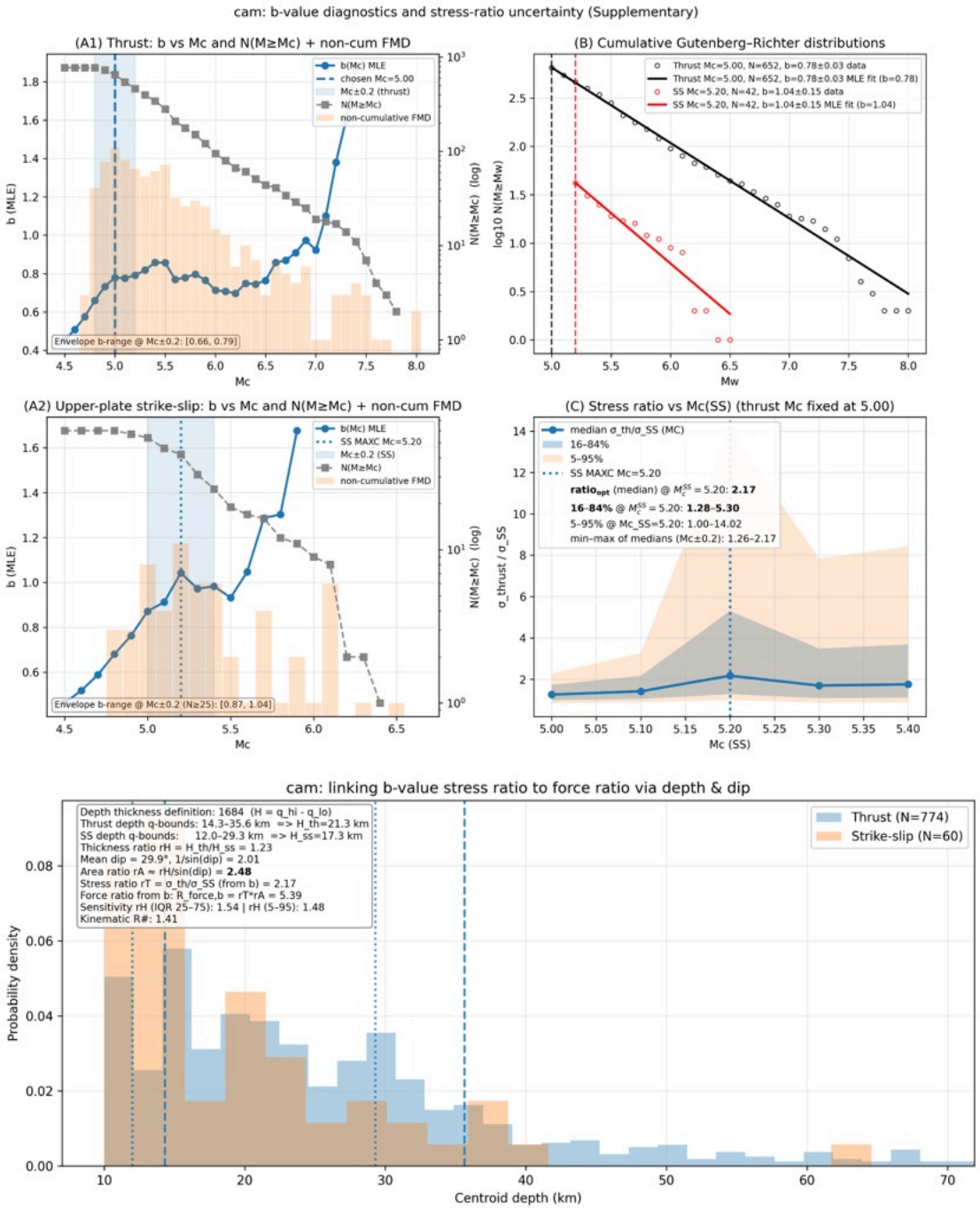


Fig. S-cam-e. Central America b-value stress-ratio estimate.

b-value and thrust-to–strike-slip stress-ratio estimates for the Central America subduction zone. See Figure SX.e description.

3-car: Caribbean

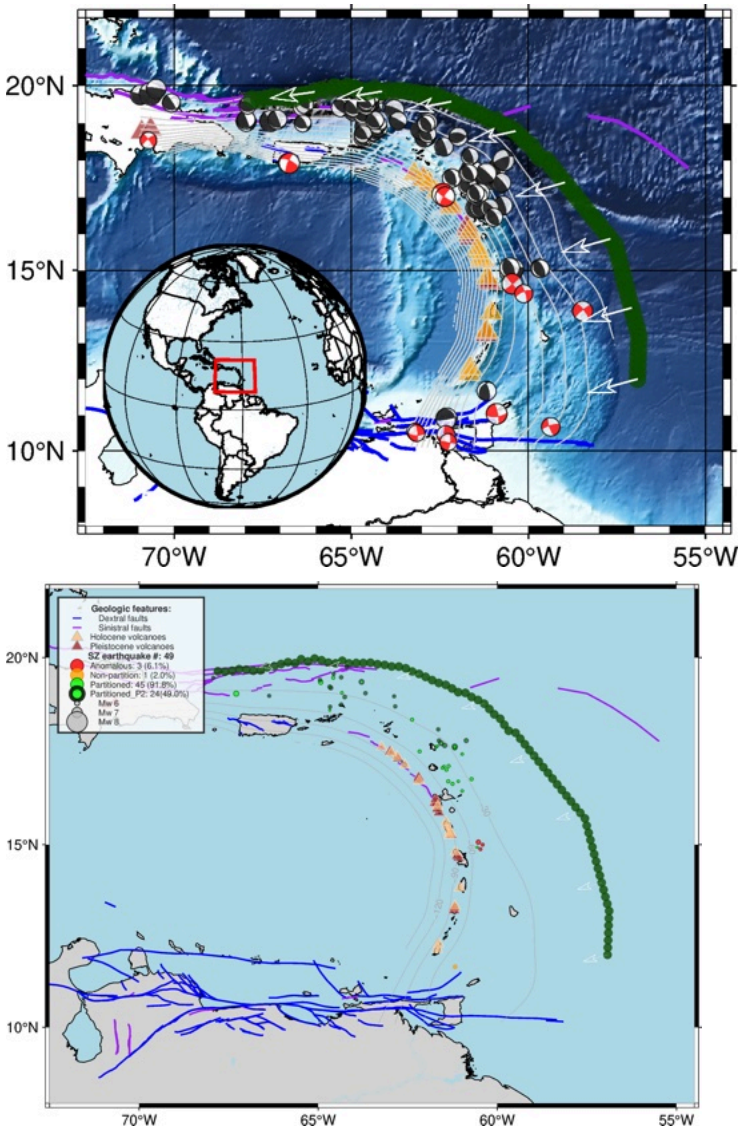


Fig. S-car-a. Caribbean tectonic setting and earthquake distribution.

Regional map and regime-colored earthquake distribution for the Caribbean subduction zone. See Figure SX.a description for plotted quantities and symbol definitions.

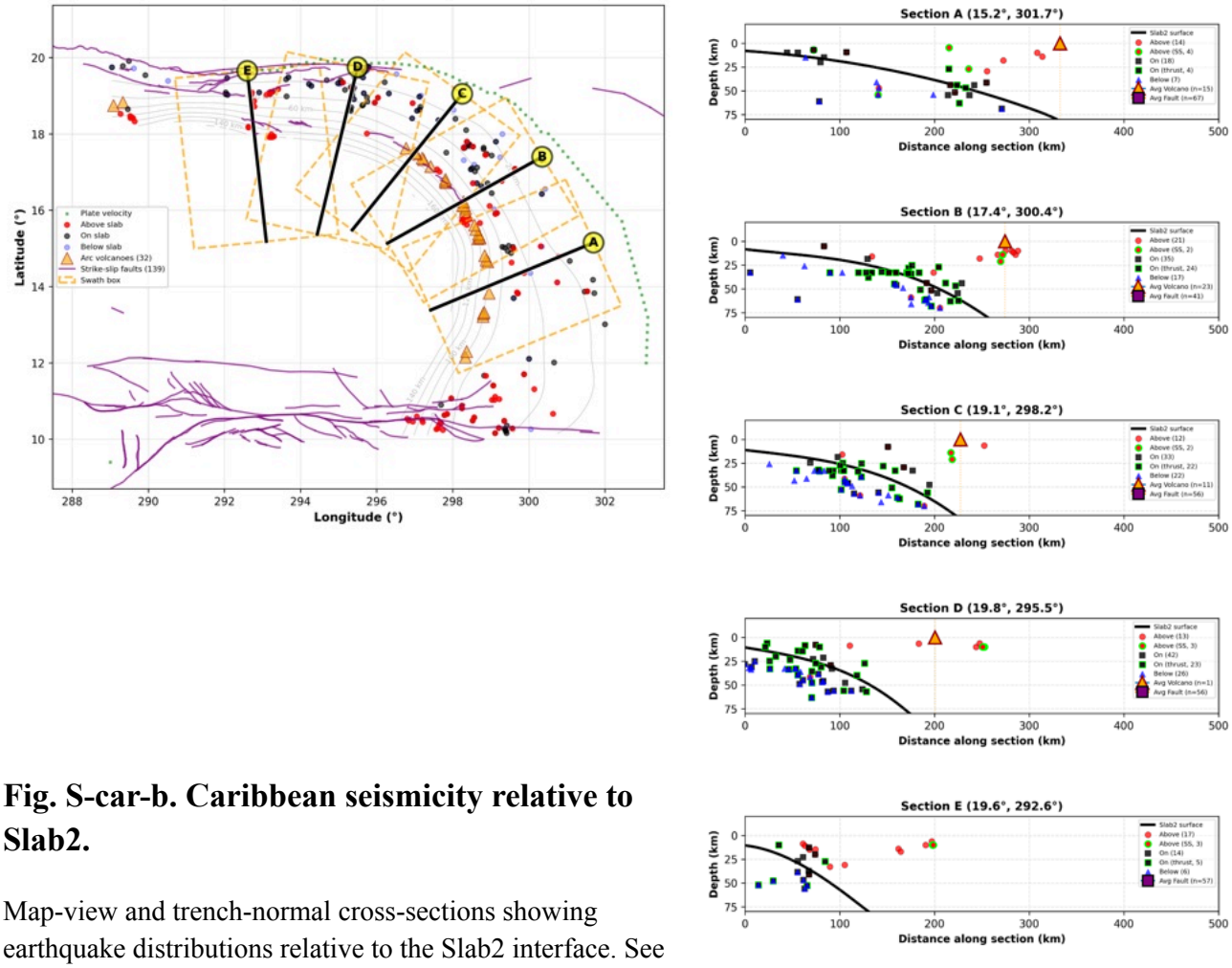


Fig. S-car-b. Caribbean seismicity relative to Slab2.

Map-view and trench-normal cross-sections showing earthquake distributions relative to the Slab2 interface. See Figure SX.b description.

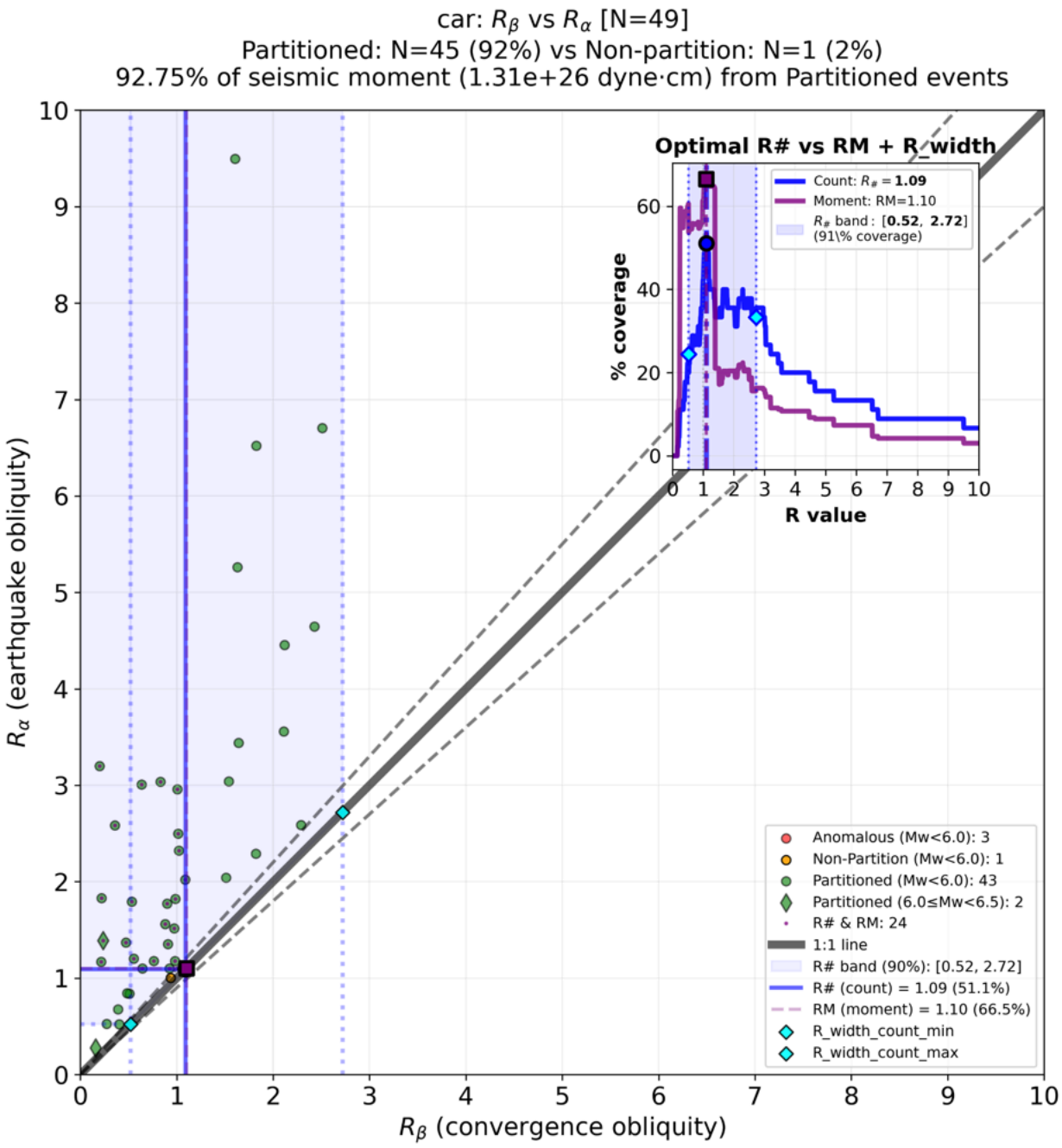


Fig. S-car-c. Caribbean regime classification in Rβ-Rα space.

Normalized regime diagram showing partitioned, non-partitioned, and anomalous events, with R#, R_M, and R#90% interval. See Figure SX.c description.

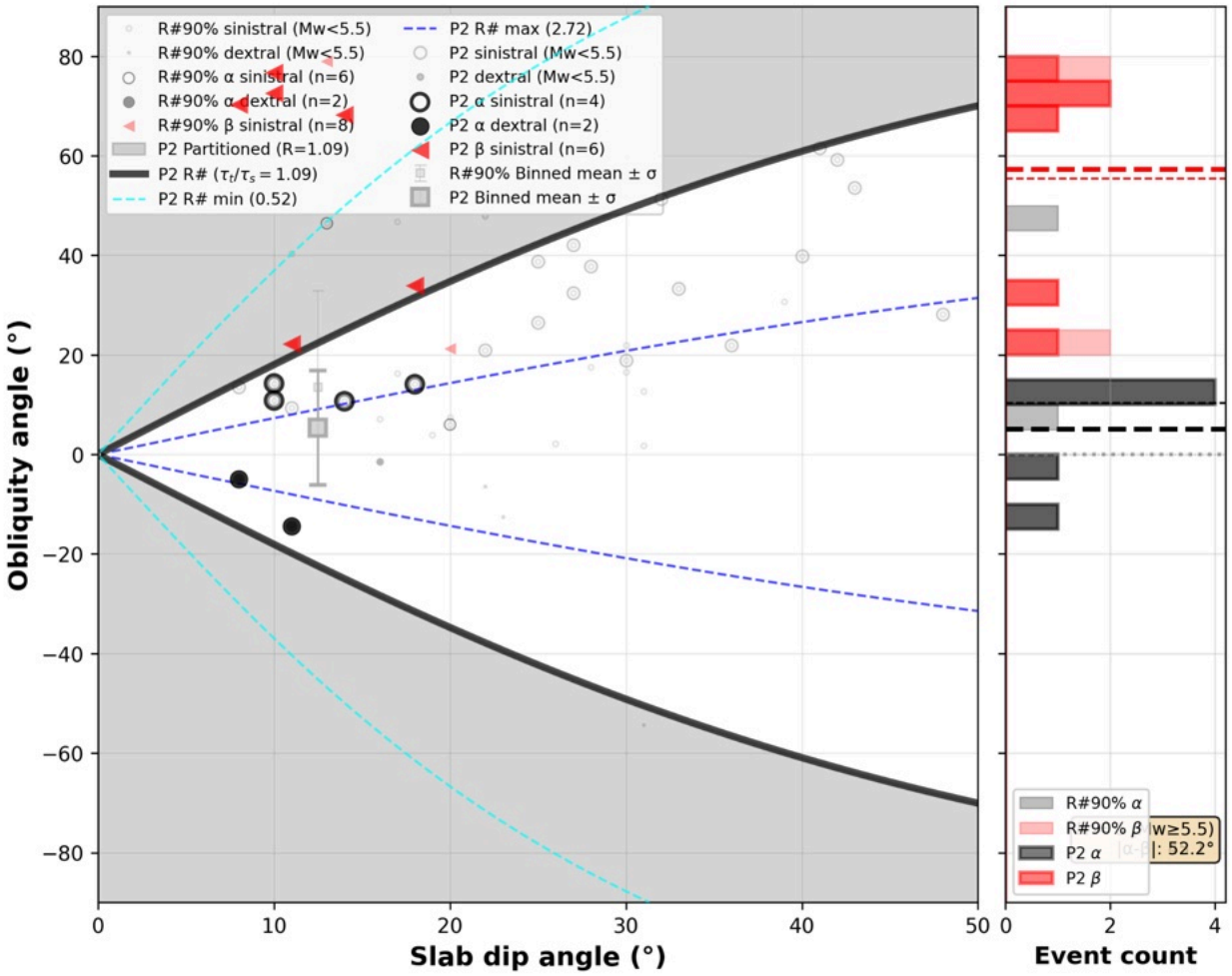


Fig. S-car-d. Caribbean obliquity–dip comparison.

Earthquake slip obliquity and convergence obliquity plotted against slab dip, compared with analytic predictions. See Figure SX.d description.

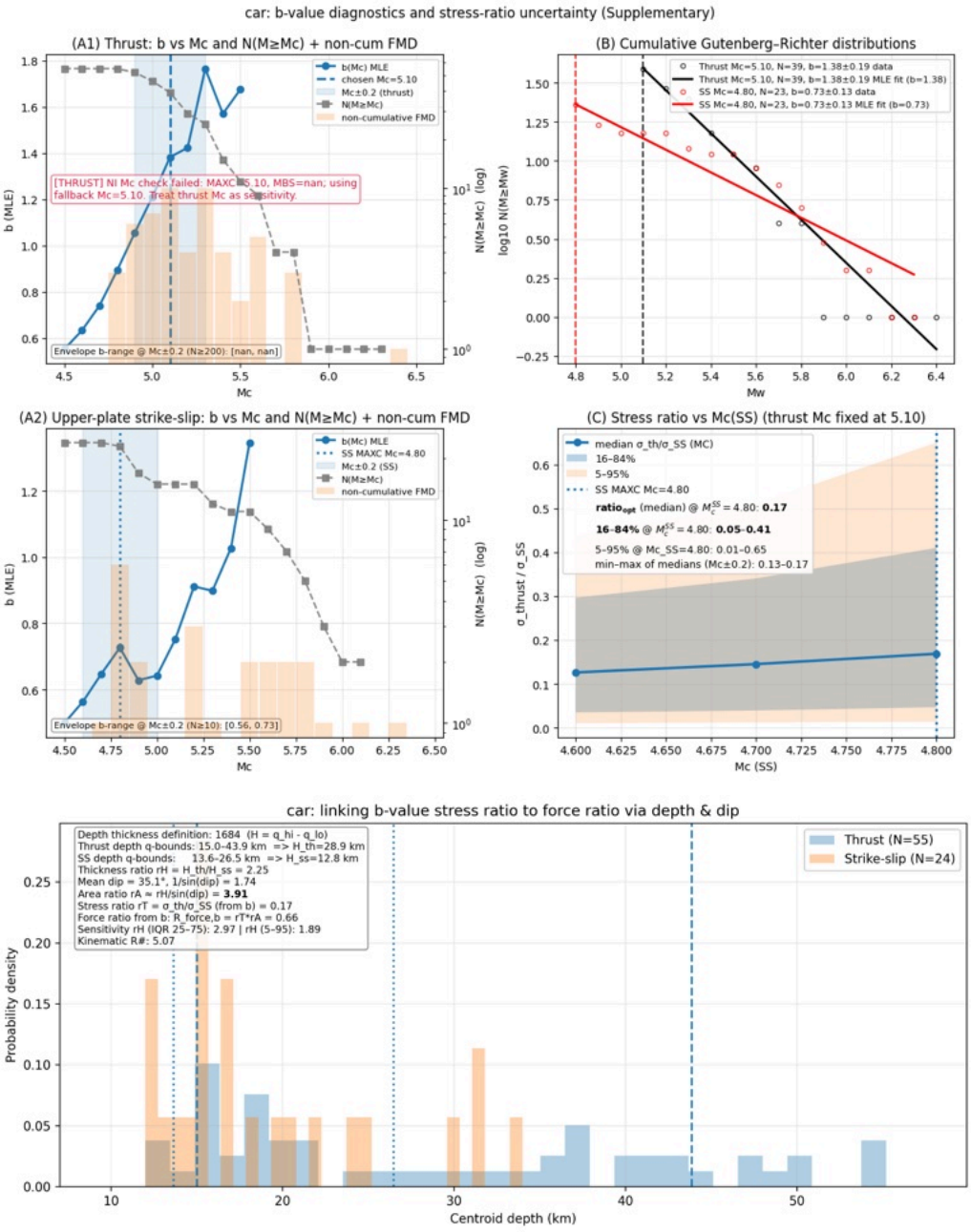


Fig. S-car-e. Caribbean b-value stress-ratio estimate.

b-value and thrust-to–strike-slip stress-ratio estimates for the Caribbean subduction zone. See Figure SX.e description.

4-izu-izu bonin mariana

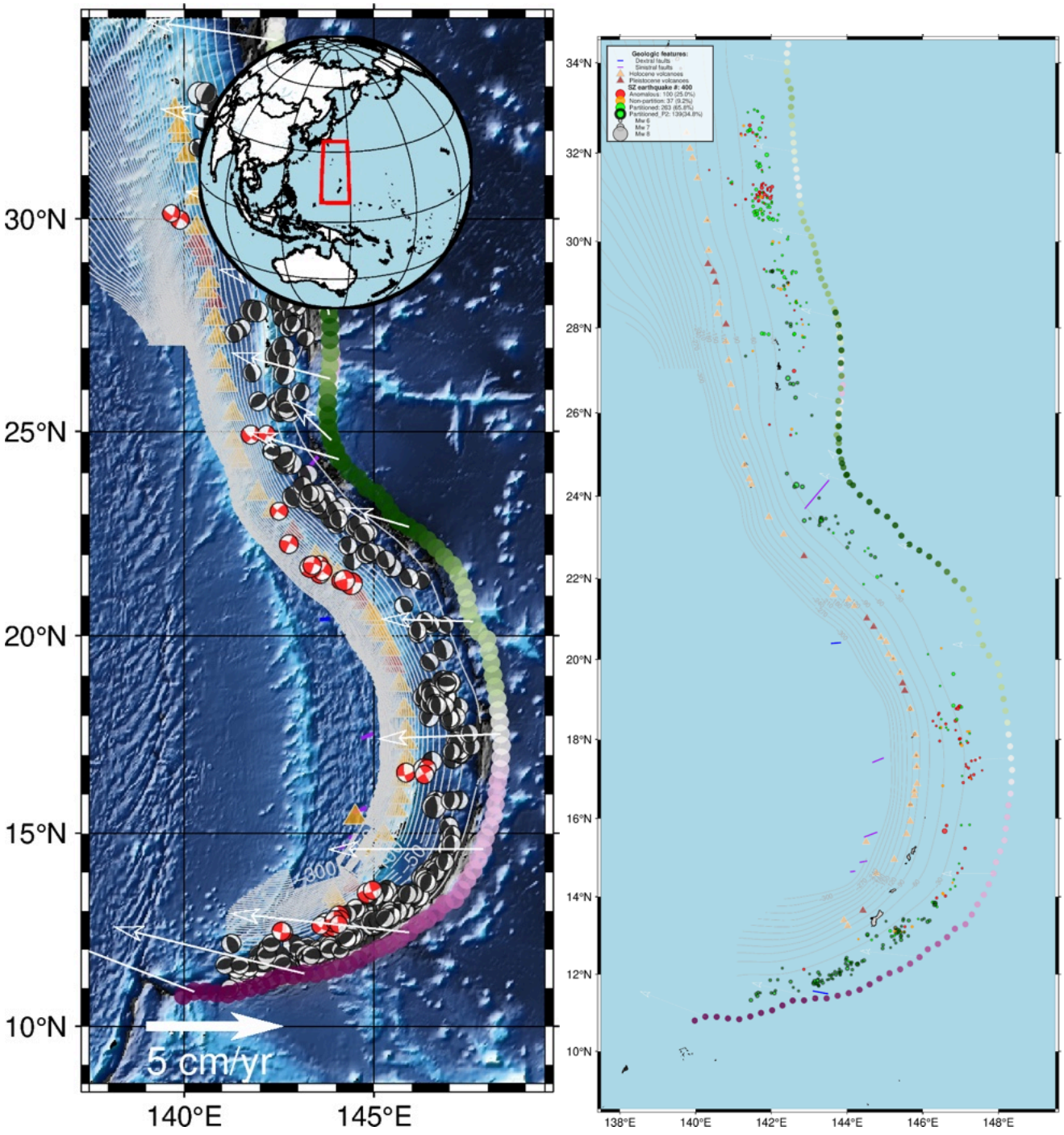


Fig. S-izu-a. Izu-Bonin-Mariana tectonic setting and earthquake distribution.

Regional map and regime-colored earthquake distribution for the Izu-Bonin-Mariana subduction zone. See Figure SX.a description for plotted quantities and symbol definitions.

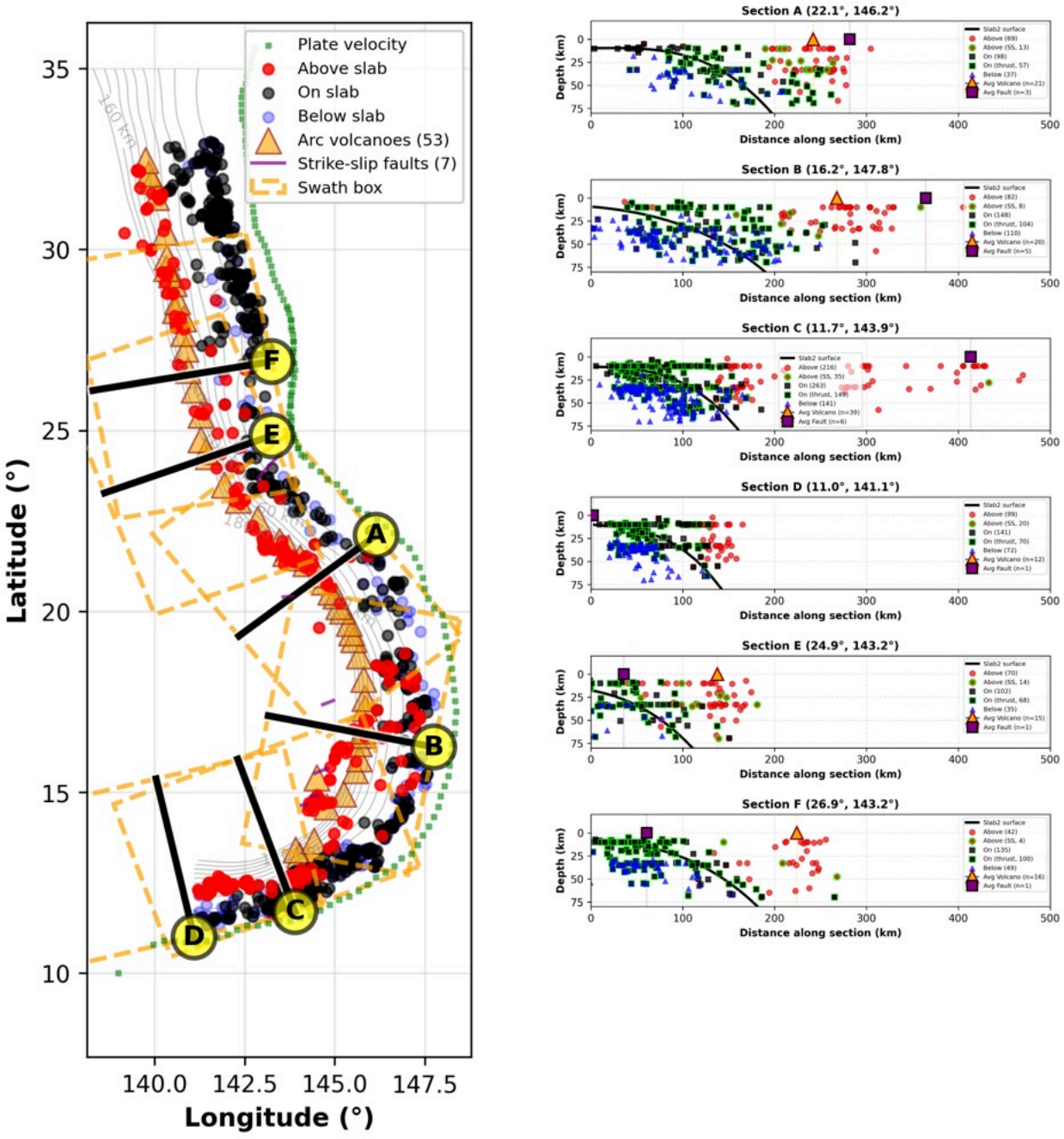


Fig. S-izu-b. Izu-Bonin-Mariana seismicity relative to Slab2.

Map-view and trench-normal cross-sections showing earthquake distributions relative to the Slab2 interface. See Figure SX.b description.

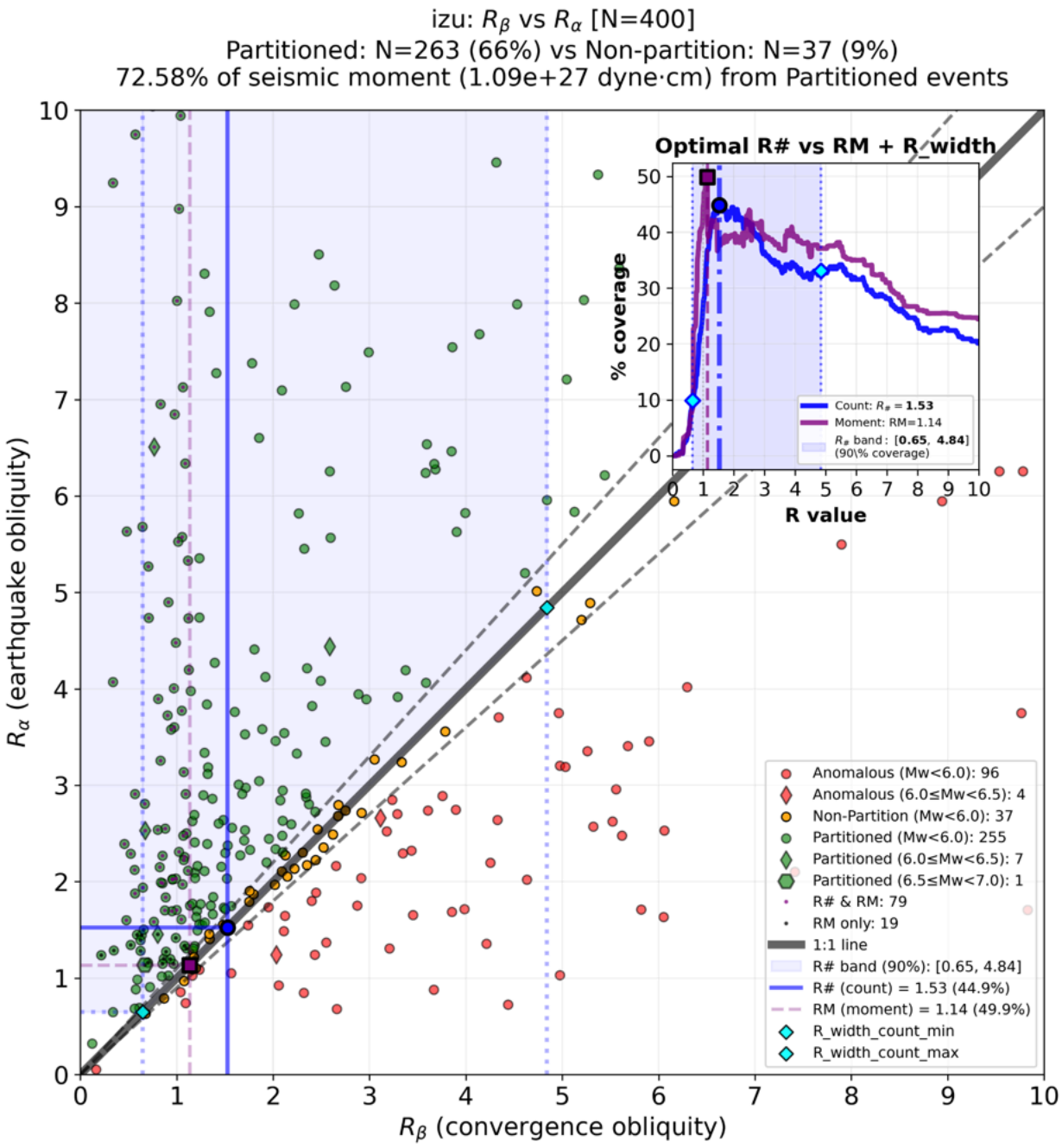


Fig. S-izu-c. Izu-Bonin-Mariana regime classification in Rβ-Rα space.

Normalized regime diagram showing partitioned, non-partitioned, and anomalous events, with R#, R_M, and R#90% interval. See Figure SX.c description.

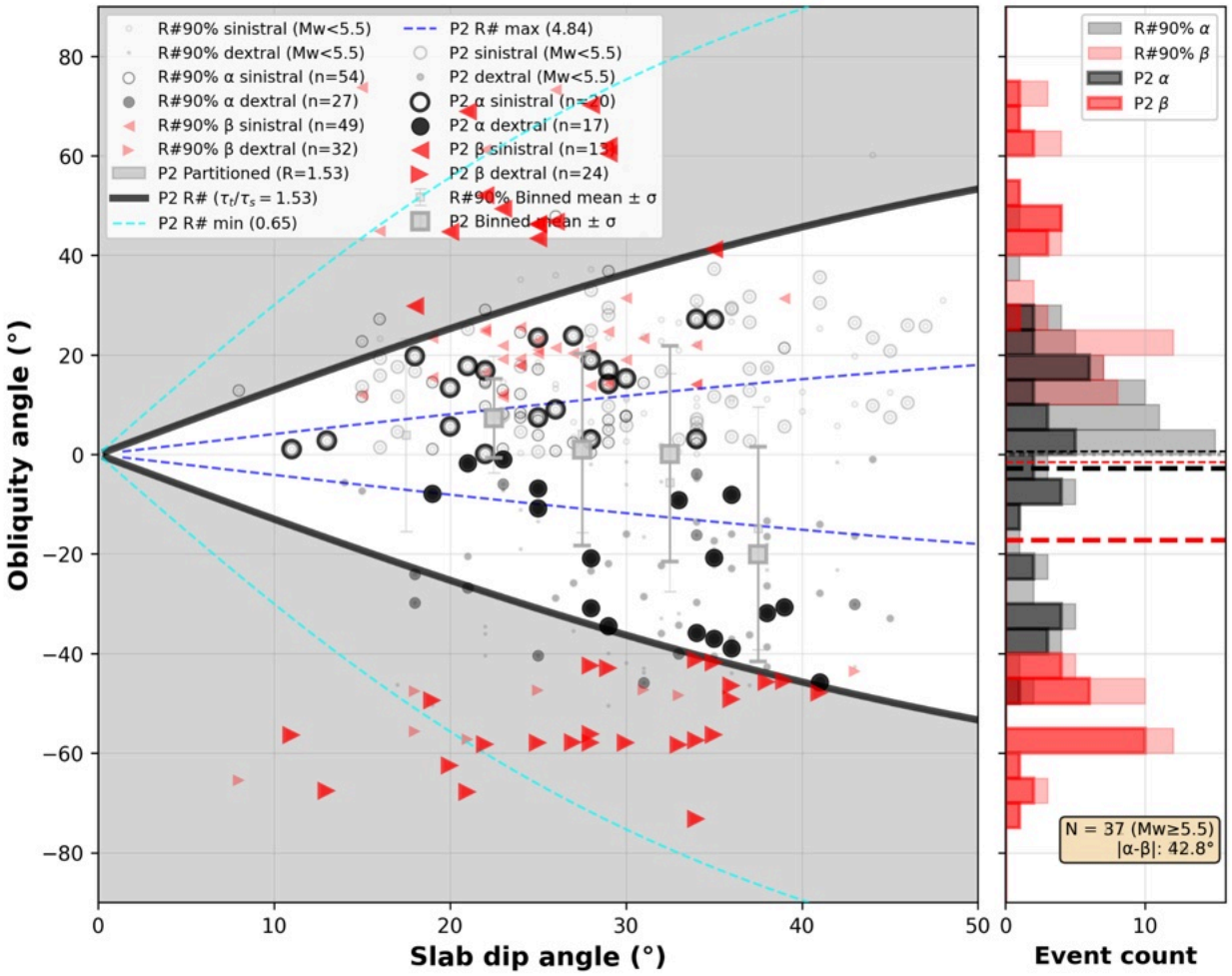


Fig. S-izu-d. Izu-Bonin-Mariana obliquity–dip comparison.

Earthquake slip obliquity and convergence obliquity plotted against slab dip, compared with analytic predictions. See Figure SX.d description.

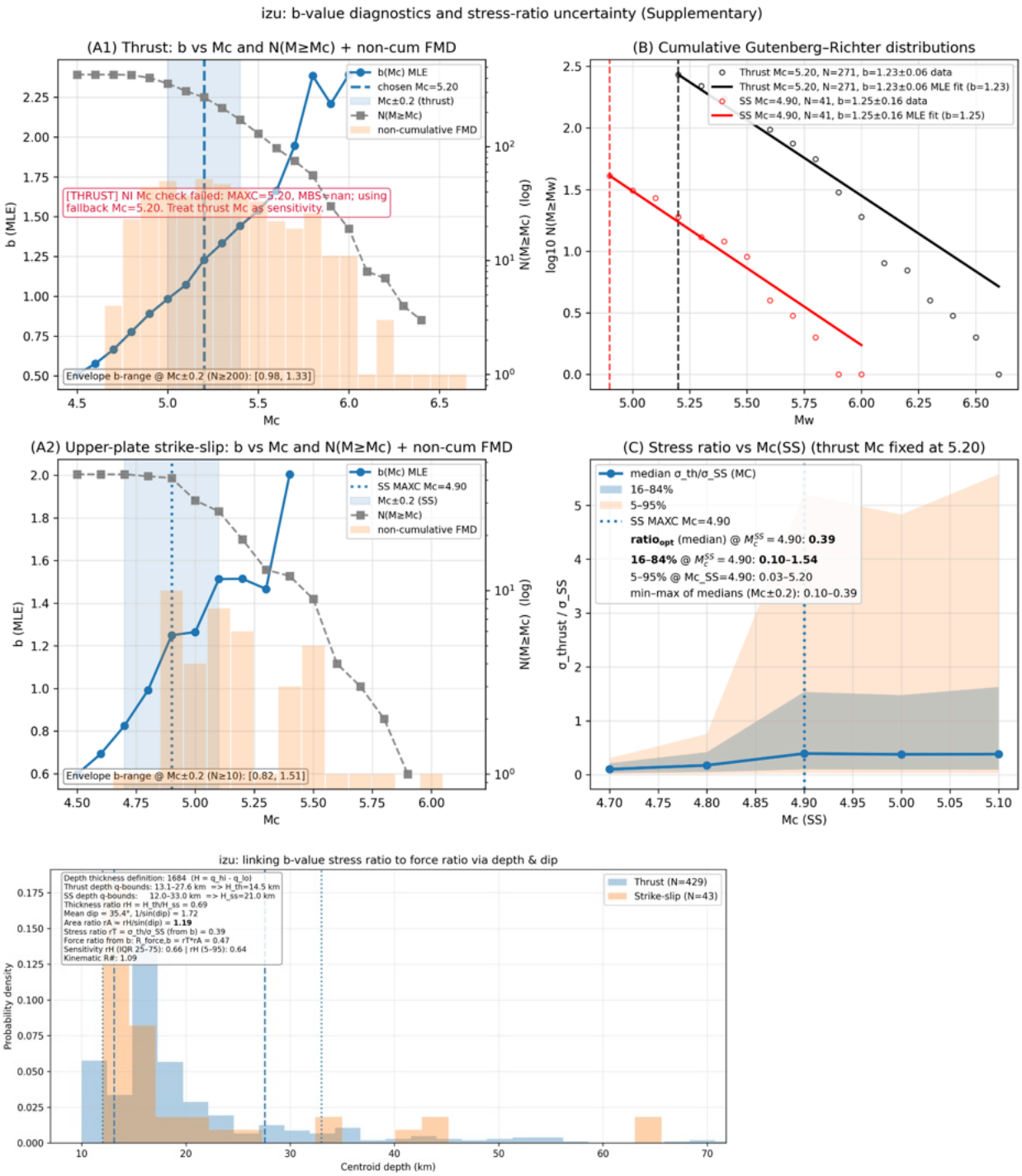


Fig. S-izu-e. Izu-Bonin-Mariana b-value stress-ratio estimate.

b-value and thrust-to–strike-slip stress-ratio estimates for the Izu-Bonin-Mariana subduction zone. See Figure SX.e description.

5-ker:Tonga-Kermadec

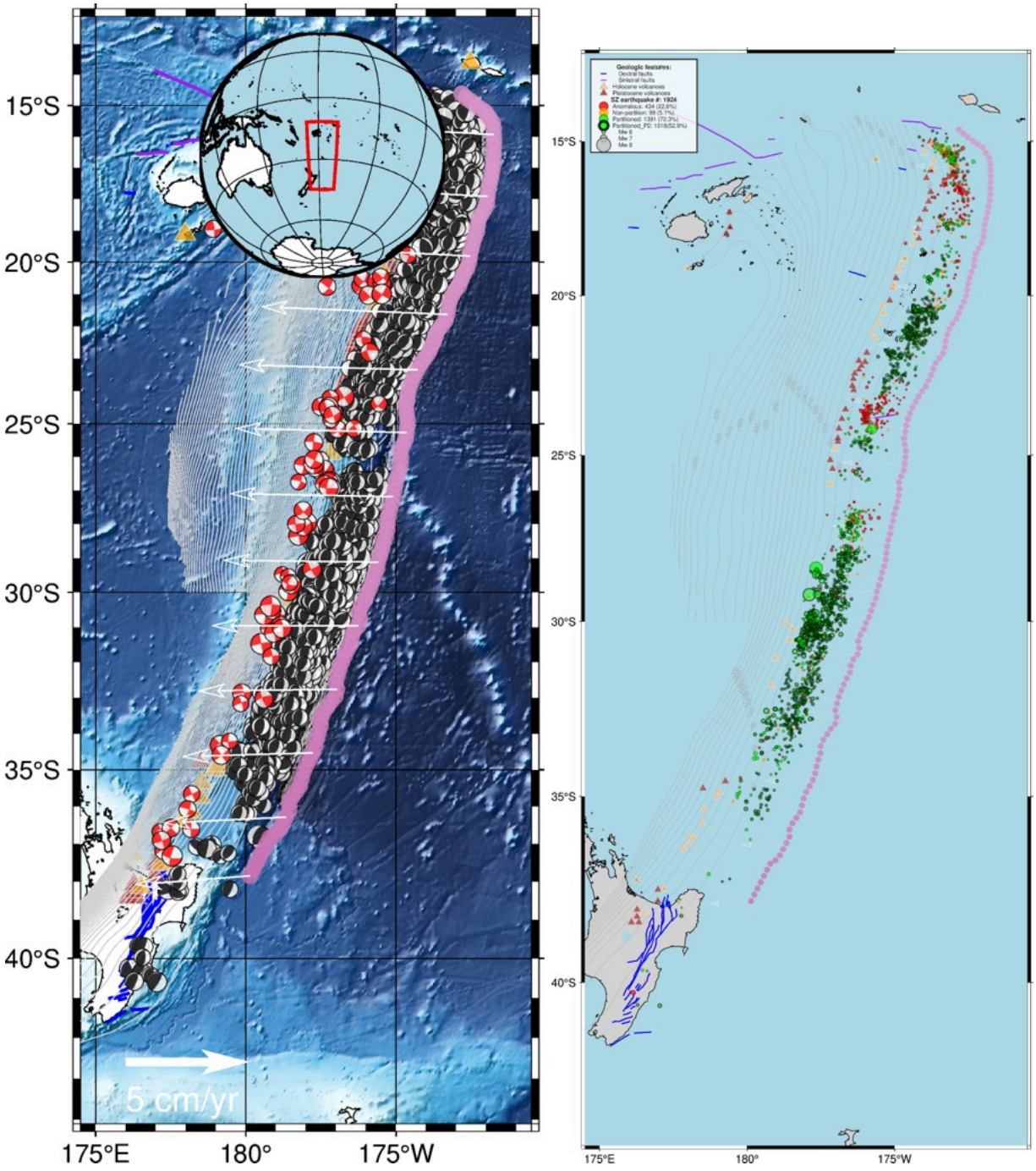


Fig. S-ker-a. Tonga-Kermadec tectonic setting and earthquake distribution.

Regional map and regime-colored earthquake distribution for the Tonga-Kermadec subduction zone. See Figure SX.a description for plotted quantities and symbol definitions.

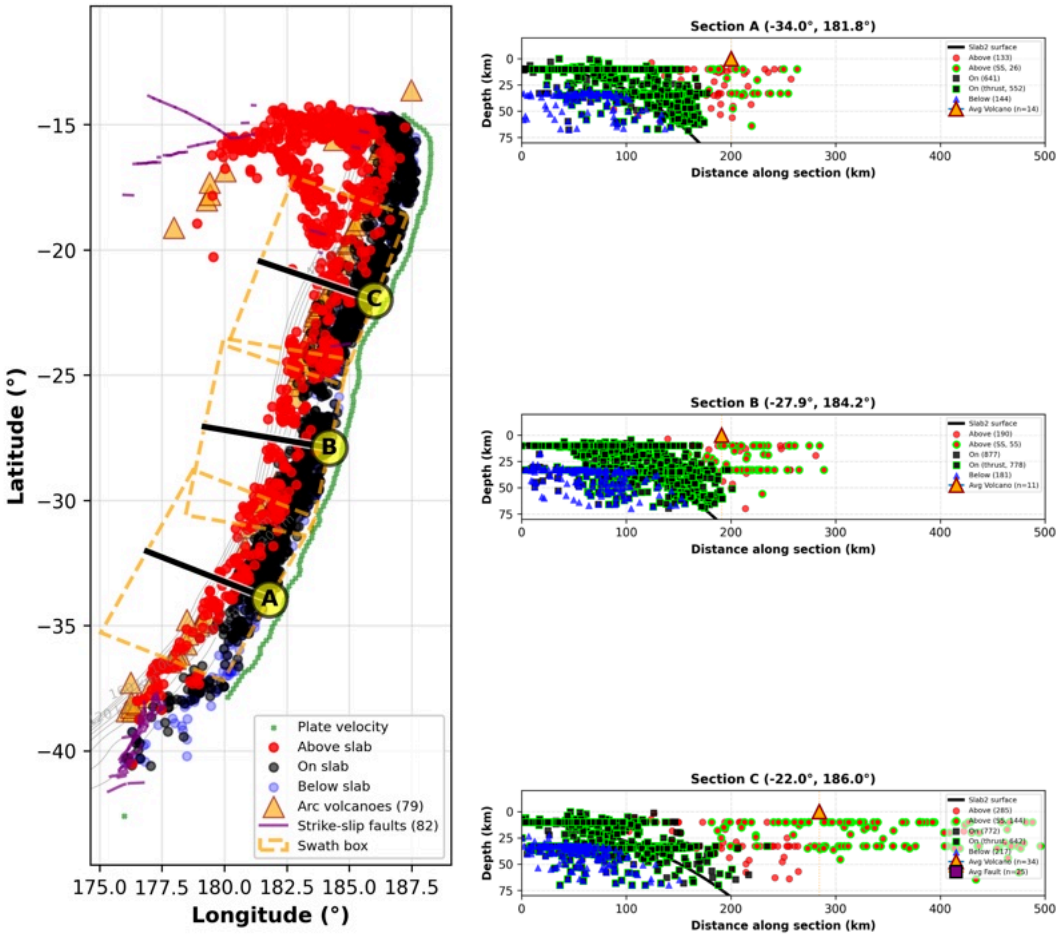


Fig. S-ker-b. Tonga-Kermadec seismicity relative to Slab2.

Map-view and trench-normal cross-sections showing earthquake distributions relative to the Slab2 interface. See Figure SX.b description.

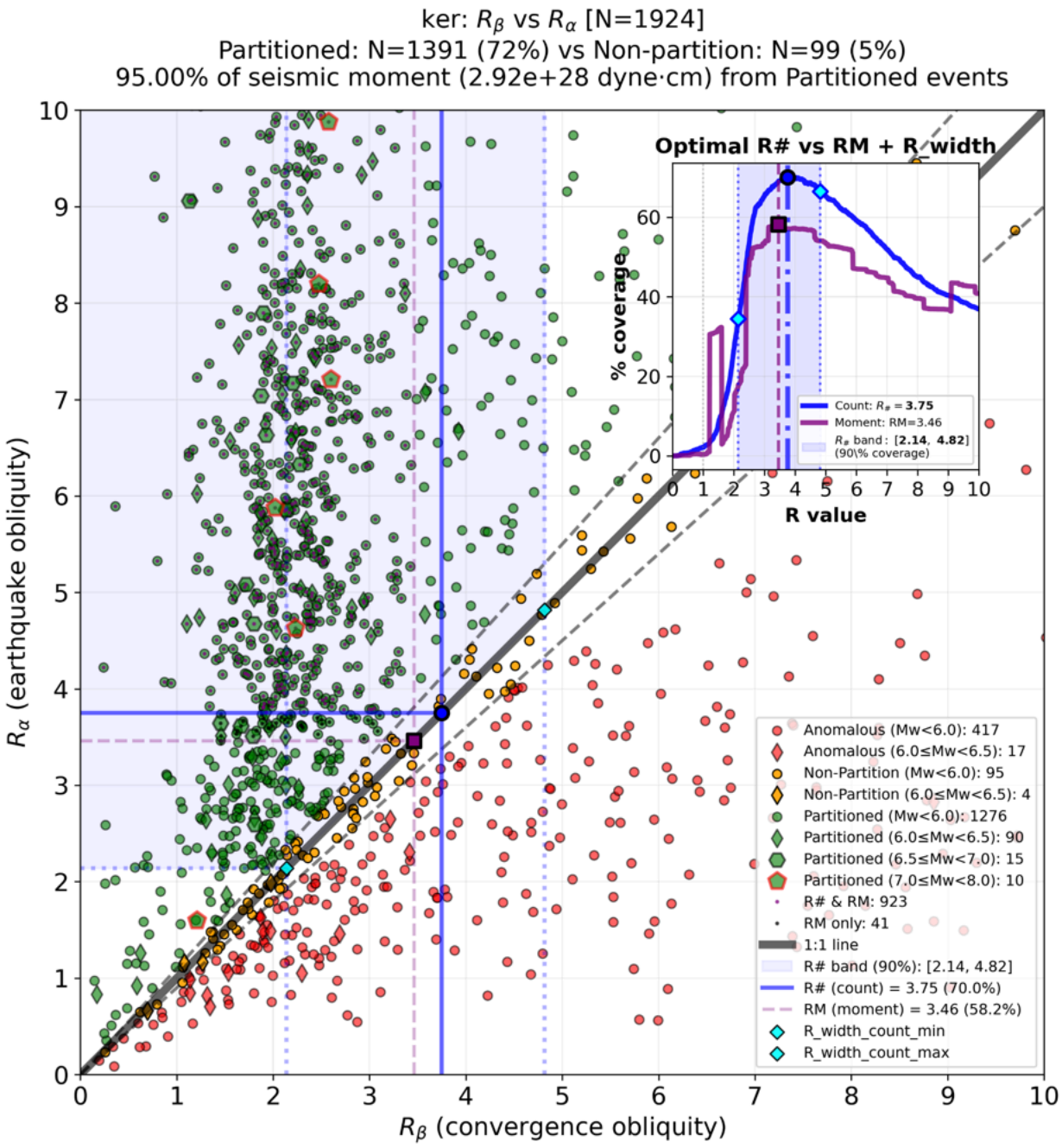


Fig. S-ker-c. Tonga-Kermadec regime classification in Rβ-Rα space.

Normalized regime diagram showing partitioned, non-partitioned, and anomalous events, with R#, R_M, and R#90% interval. See Figure SX.c description.

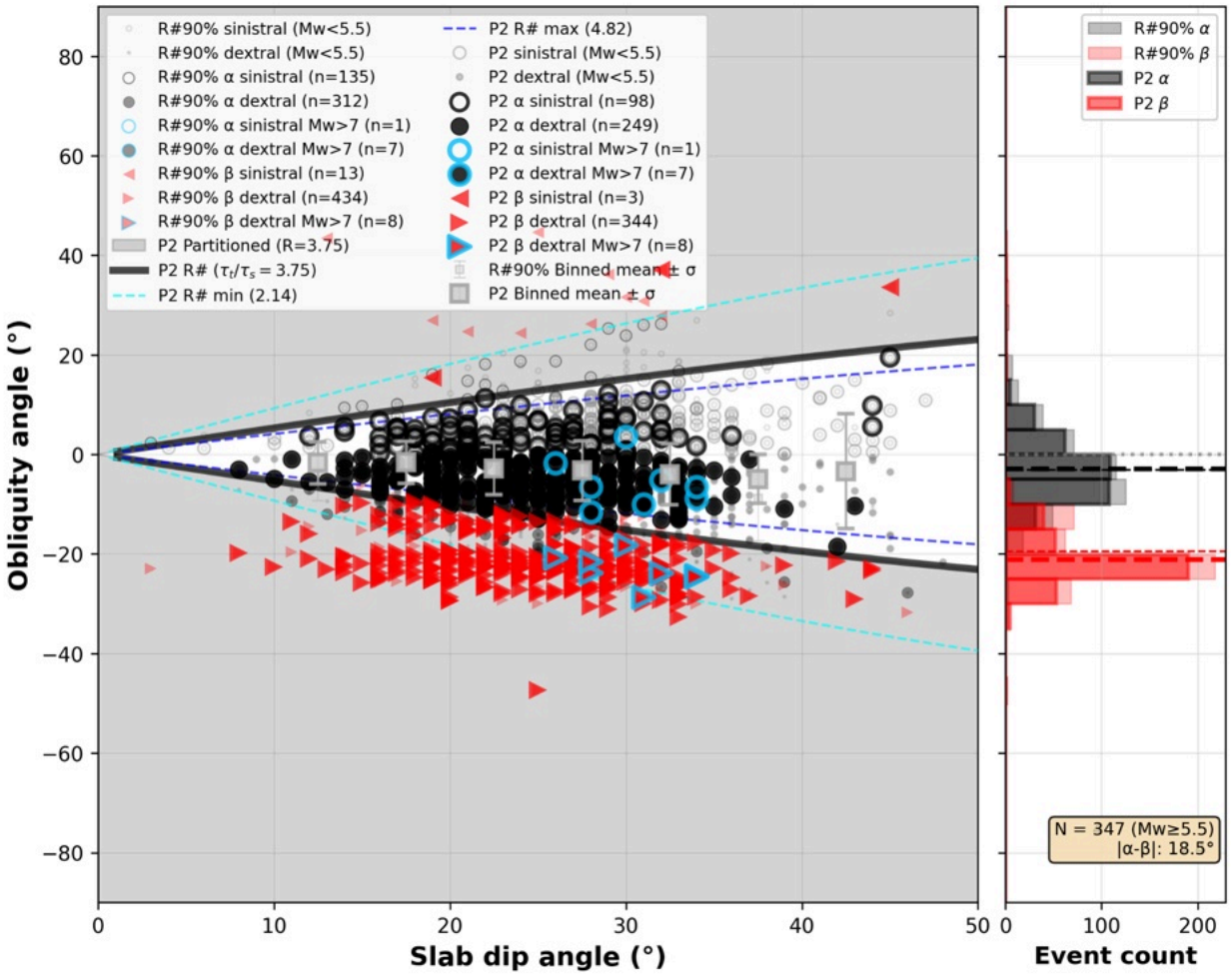


Fig. S-ker-d. Tonga-Kermadec obliquity–dip comparison.

Earthquake slip obliquity and convergence obliquity plotted against slab dip, compared with analytic predictions. See Figure SX.d description.

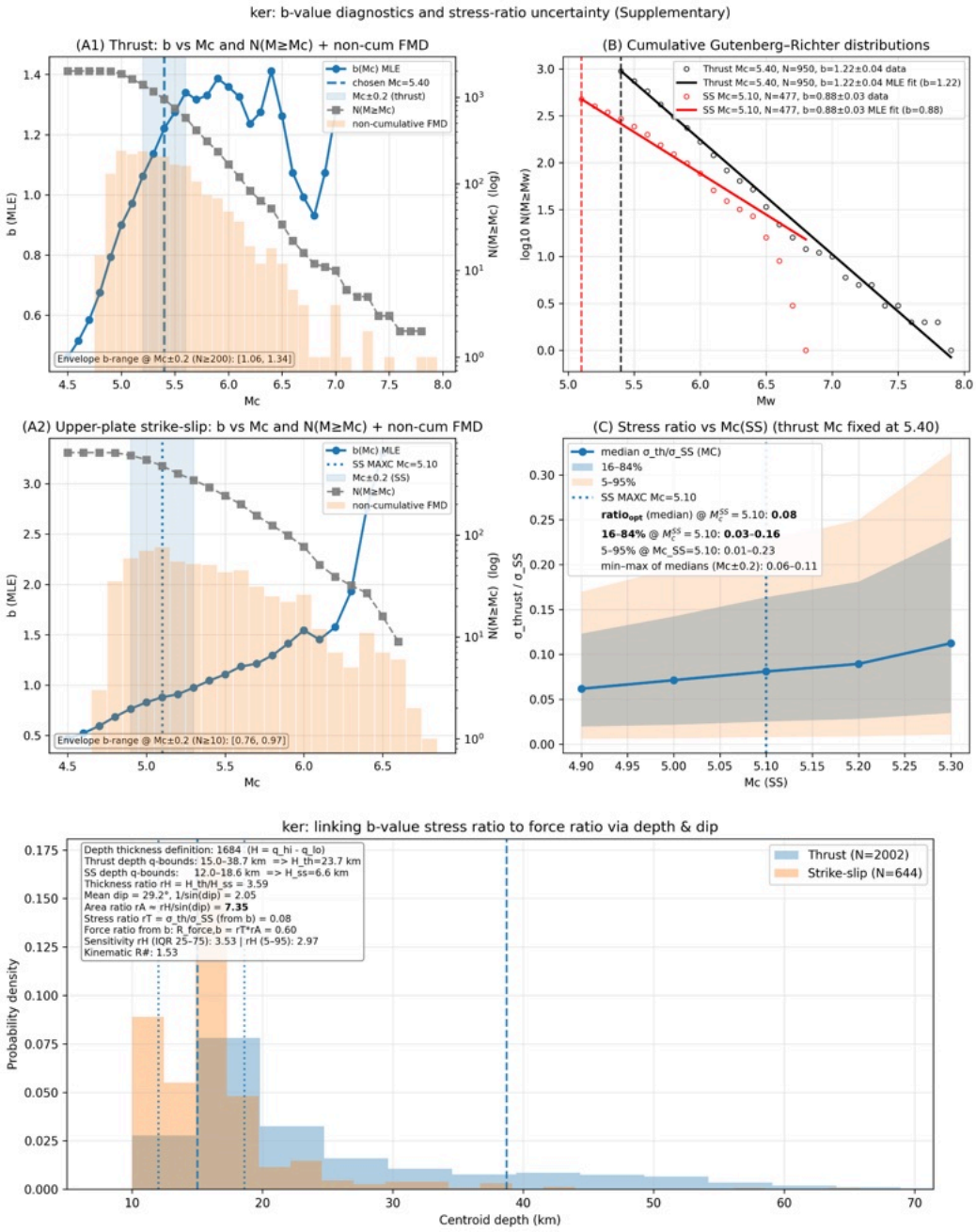
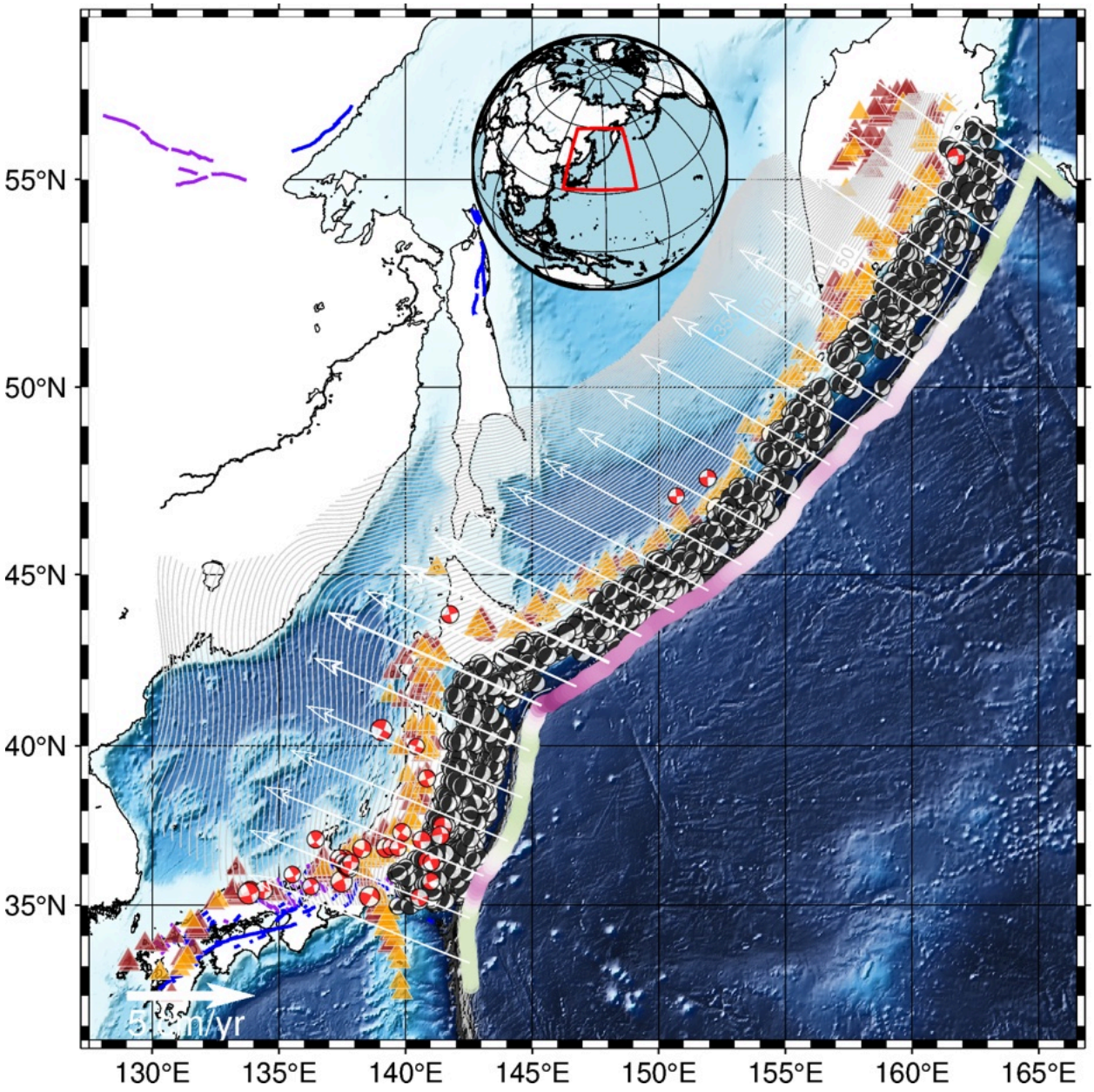


Fig. S-ker-e. Tonga-Kermadec b-value stress-ratio estimate.

b-value and thrust-to–strike-slip stress-ratio estimates for the Tonga-Kermadec subduction zone. See Figure SX.e description.

6-kur:Kuriles-Japan



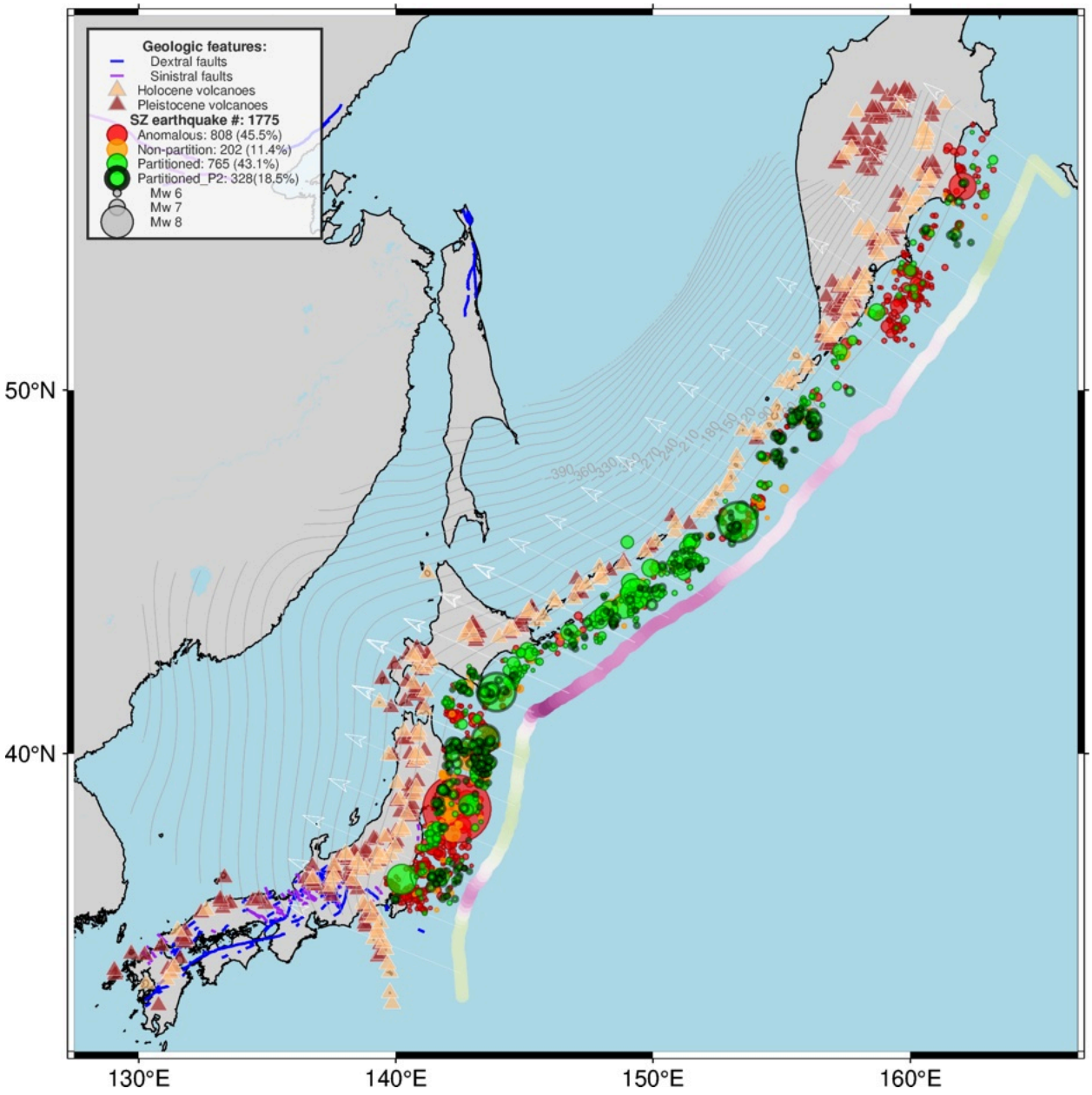
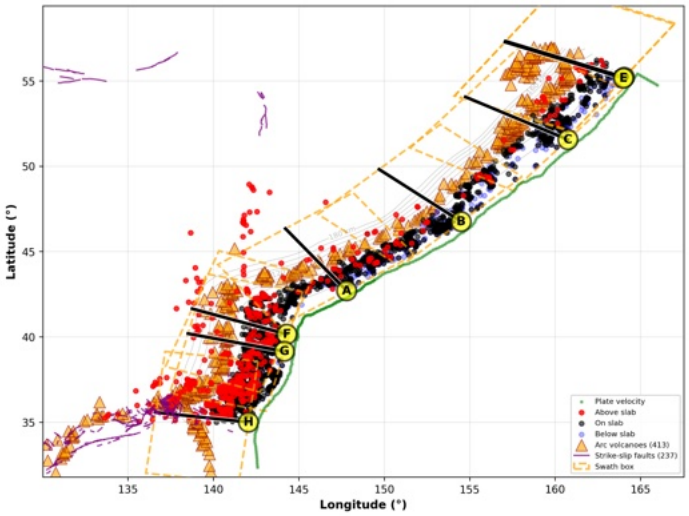


Fig. S-kur-a. Kuriles tectonic setting and earthquake distribution.

Regional map and regime-colored earthquake distribution for the Kuriles subduction zone. See Figure SX.a description for plotted quantities and symbol definitions.



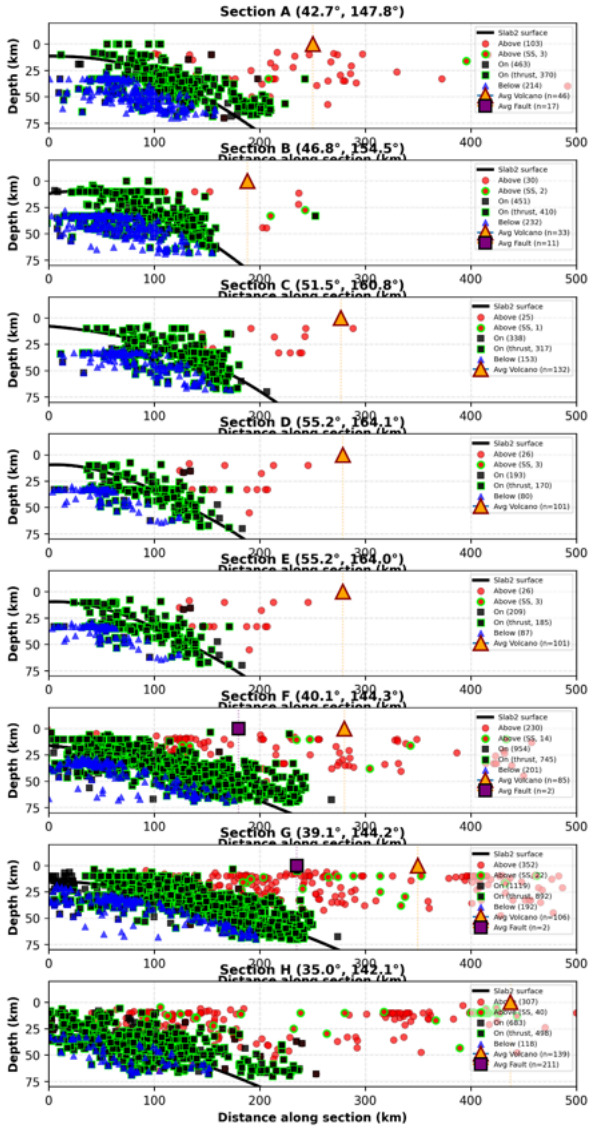


Fig. S-kur-b. Kuriles seismicity relative to Slab2.

Map-view and trench-normal cross-sections showing earthquake distributions relative to the Slab2 interface. See Figure SX.b description.

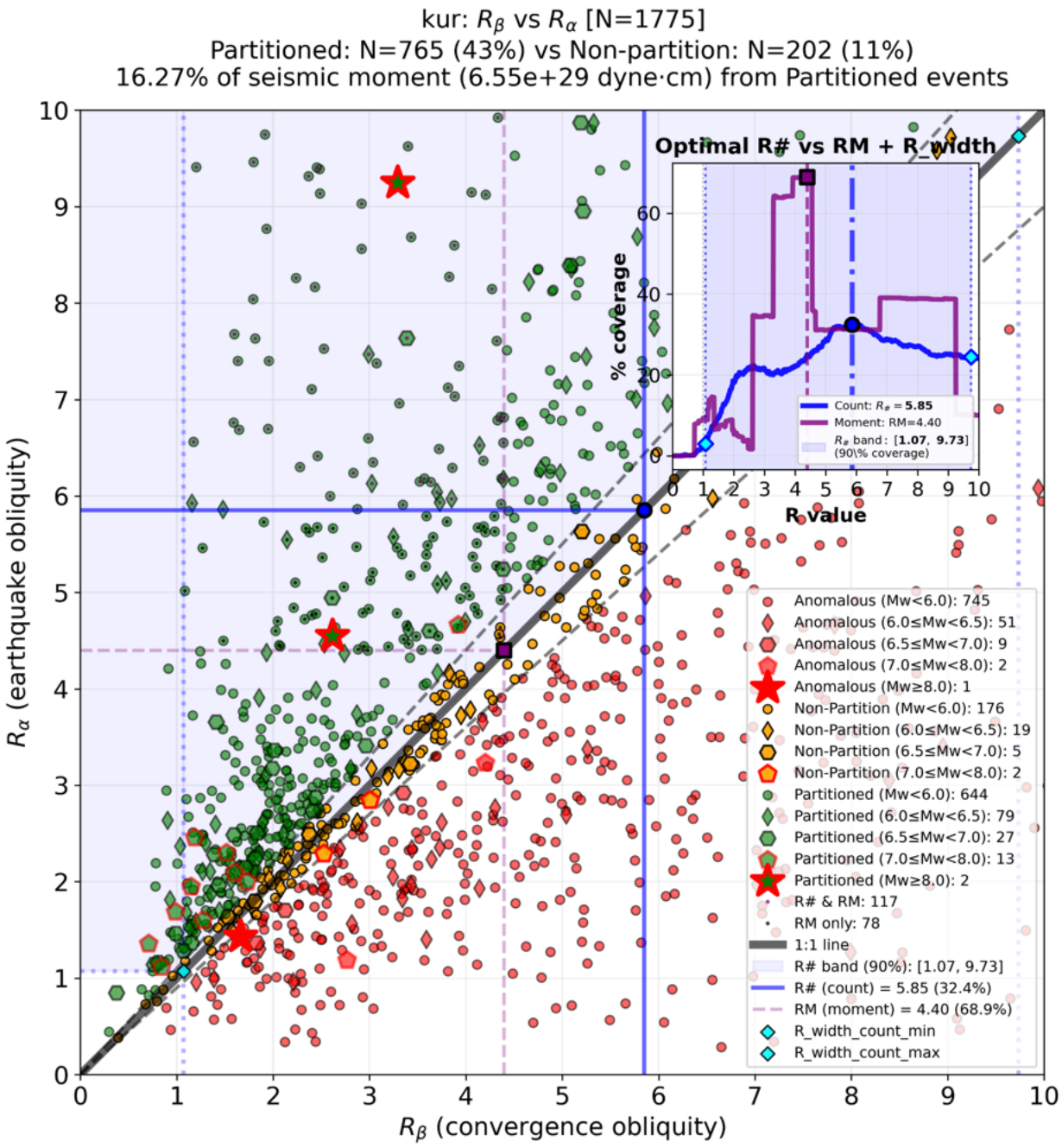


Fig. S-kur-c. Kuriles regime classification in Rβ-Rα space.

Normalized regime diagram showing partitioned, non-partitioned, and anomalous events, with R#, R_M, and R#90% interval. See Figure SX.c description.

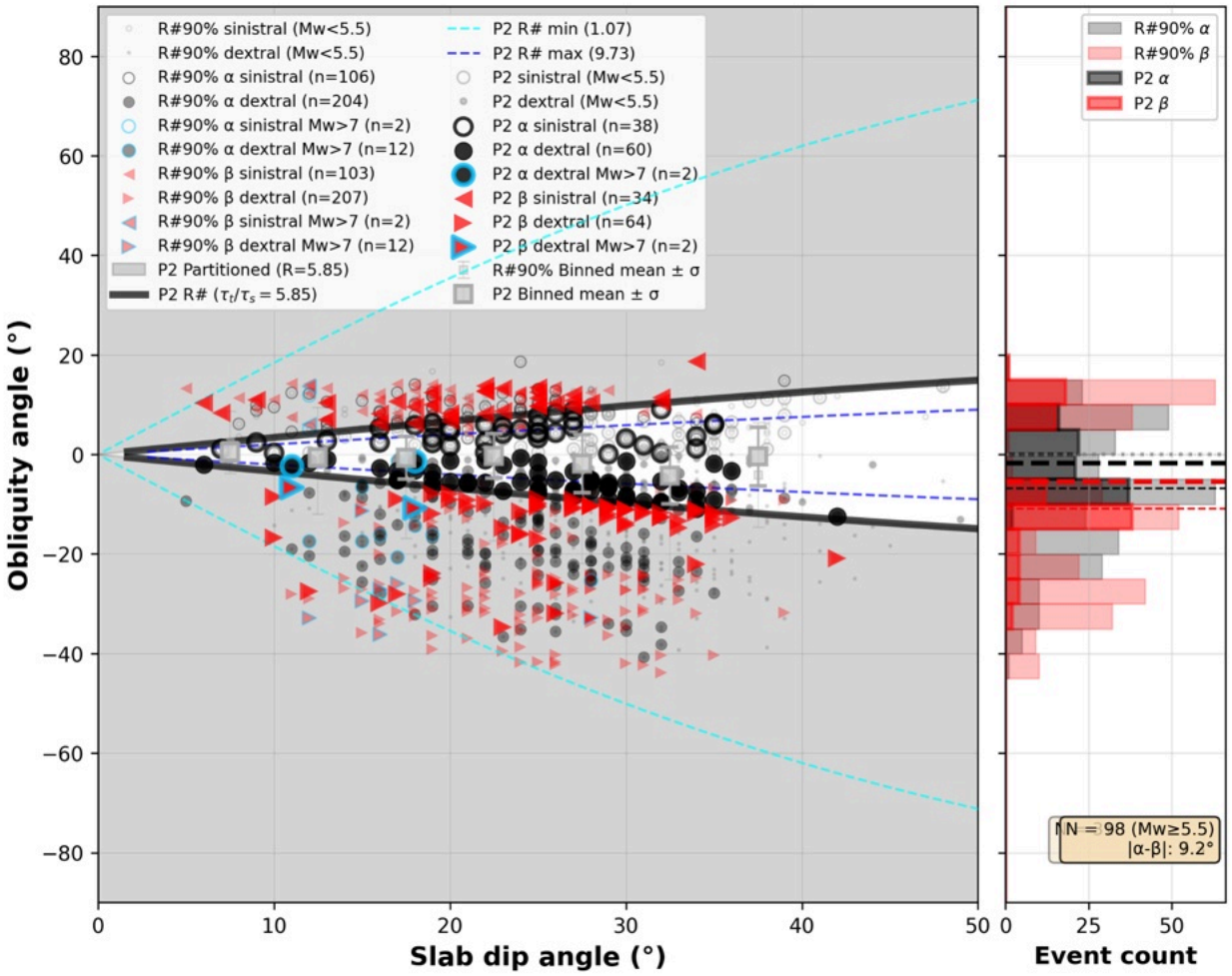


Fig. S-kur-d. Kuriles obliquity–dip comparison.

Earthquake slip obliquity and convergence obliquity plotted against slab dip, compared with analytic predictions. See Figure SX.d description.

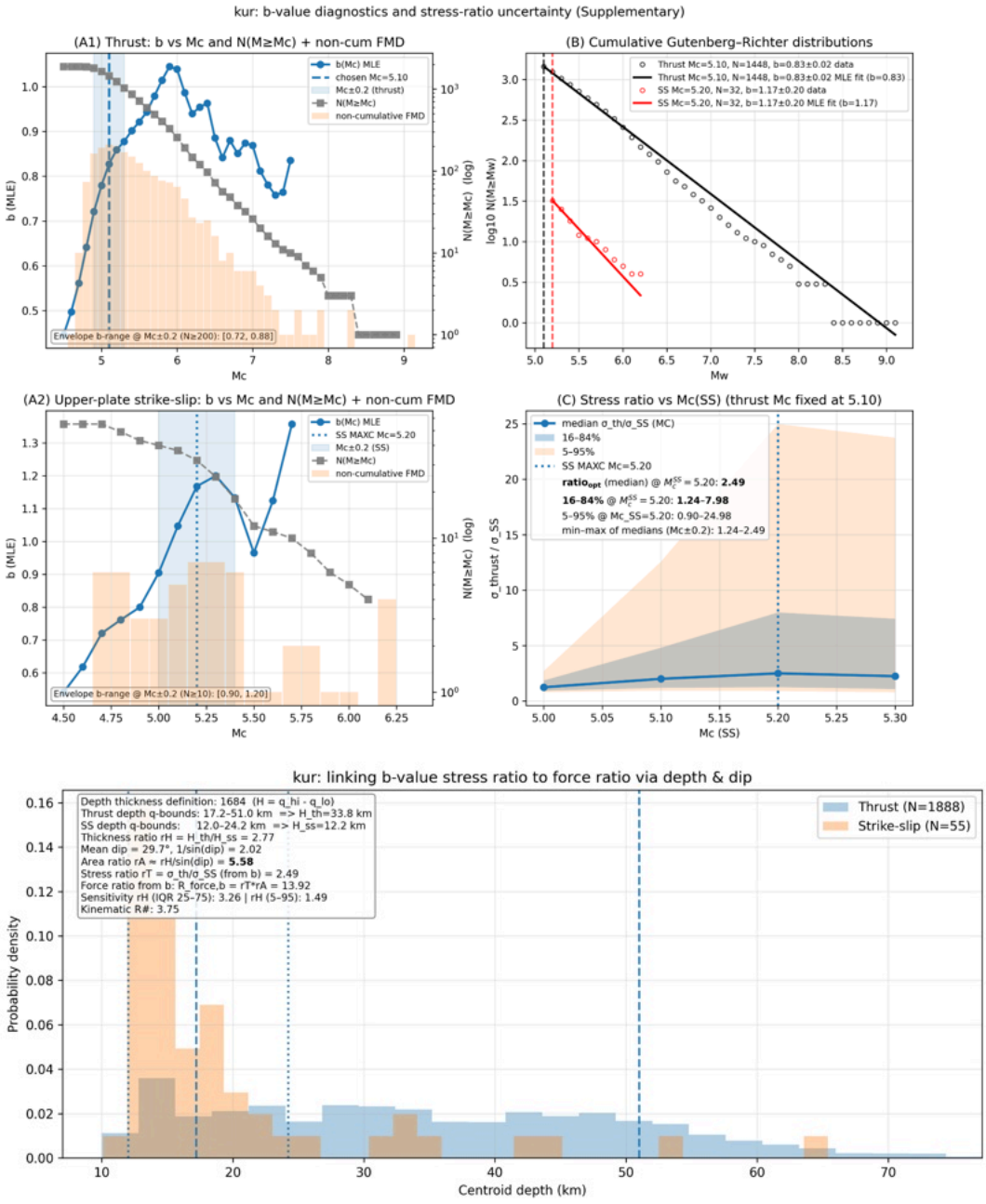


Fig. S-kur-e. Kuriles b-value stress-ratio estimate.

b-value and thrust-to–strike-slip stress-ratio estimates for the Kuriles subduction zone. See Figure SX.e description.

7-man:Manilla

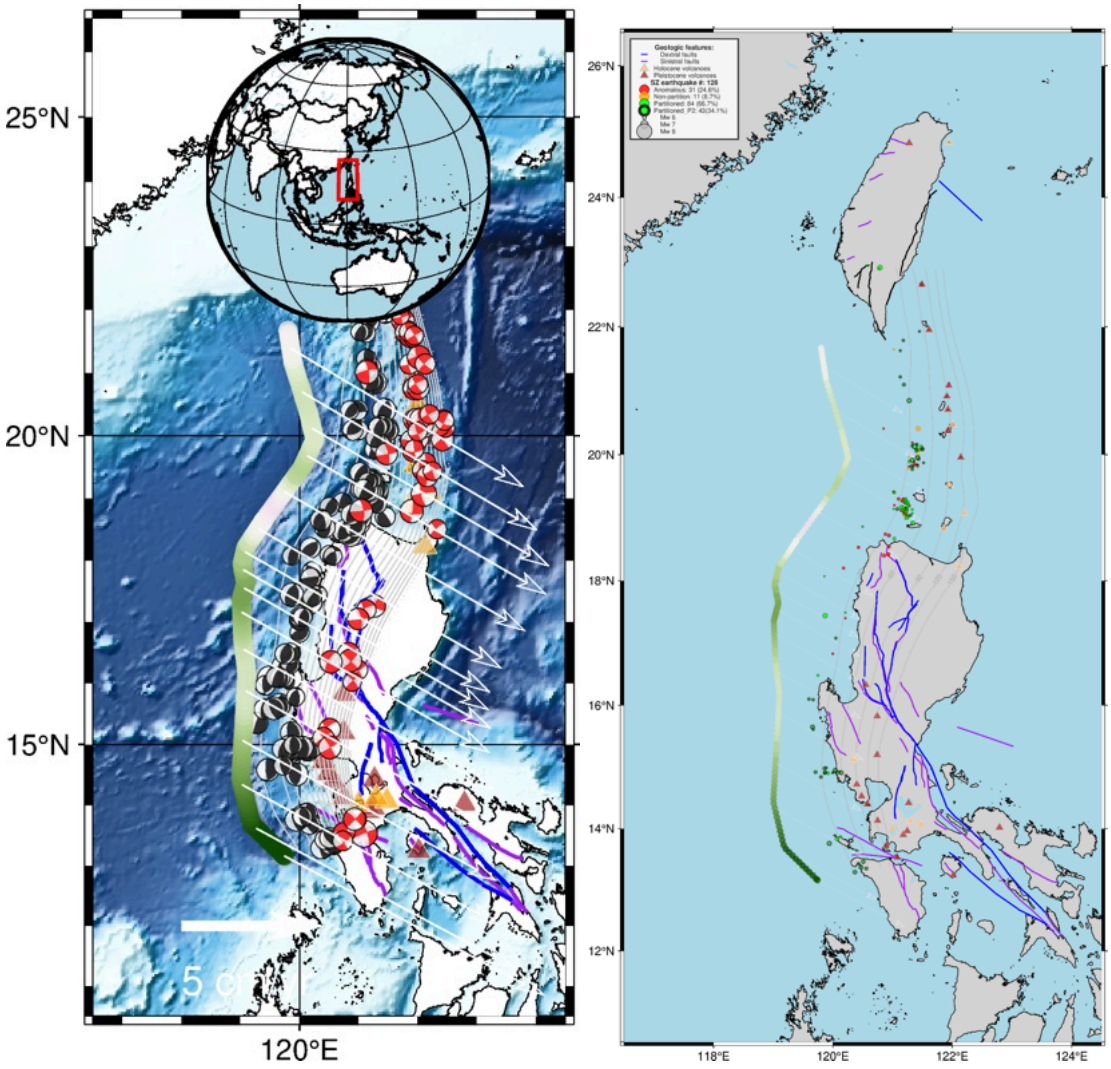


Fig. S-man-a. Manilla tectonic setting and earthquake distribution.

Regional map and regime-colored earthquake distribution for the Manilla subduction zone. See Figure SX.a description for plotted quantities and symbol definitions.

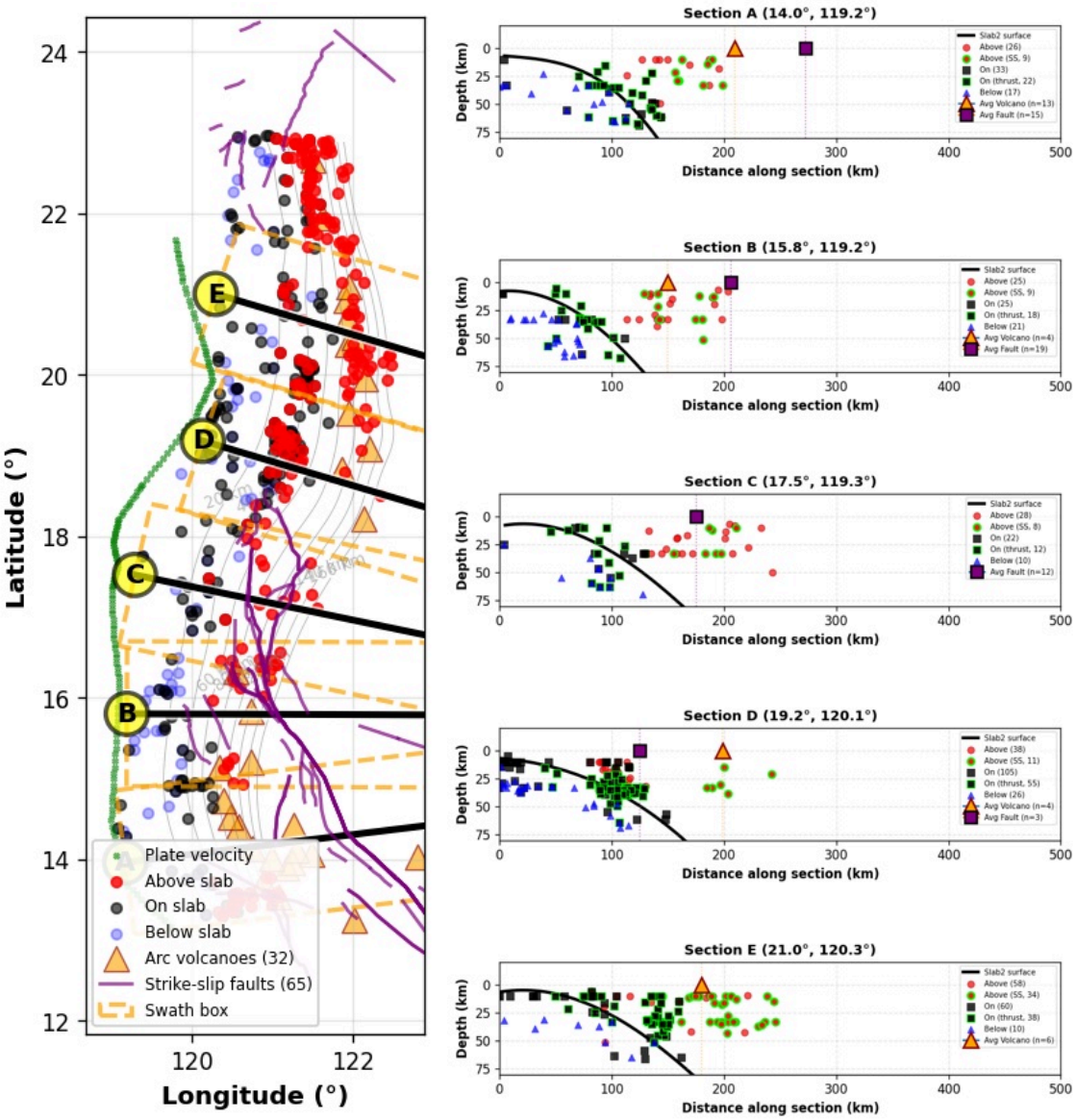


Fig. S-man-b. Manilla seismicity relative to Slab2.

Map-view and trench-normal cross-sections showing earthquake distributions relative to the Slab2 interface. See Figure SX.b description.

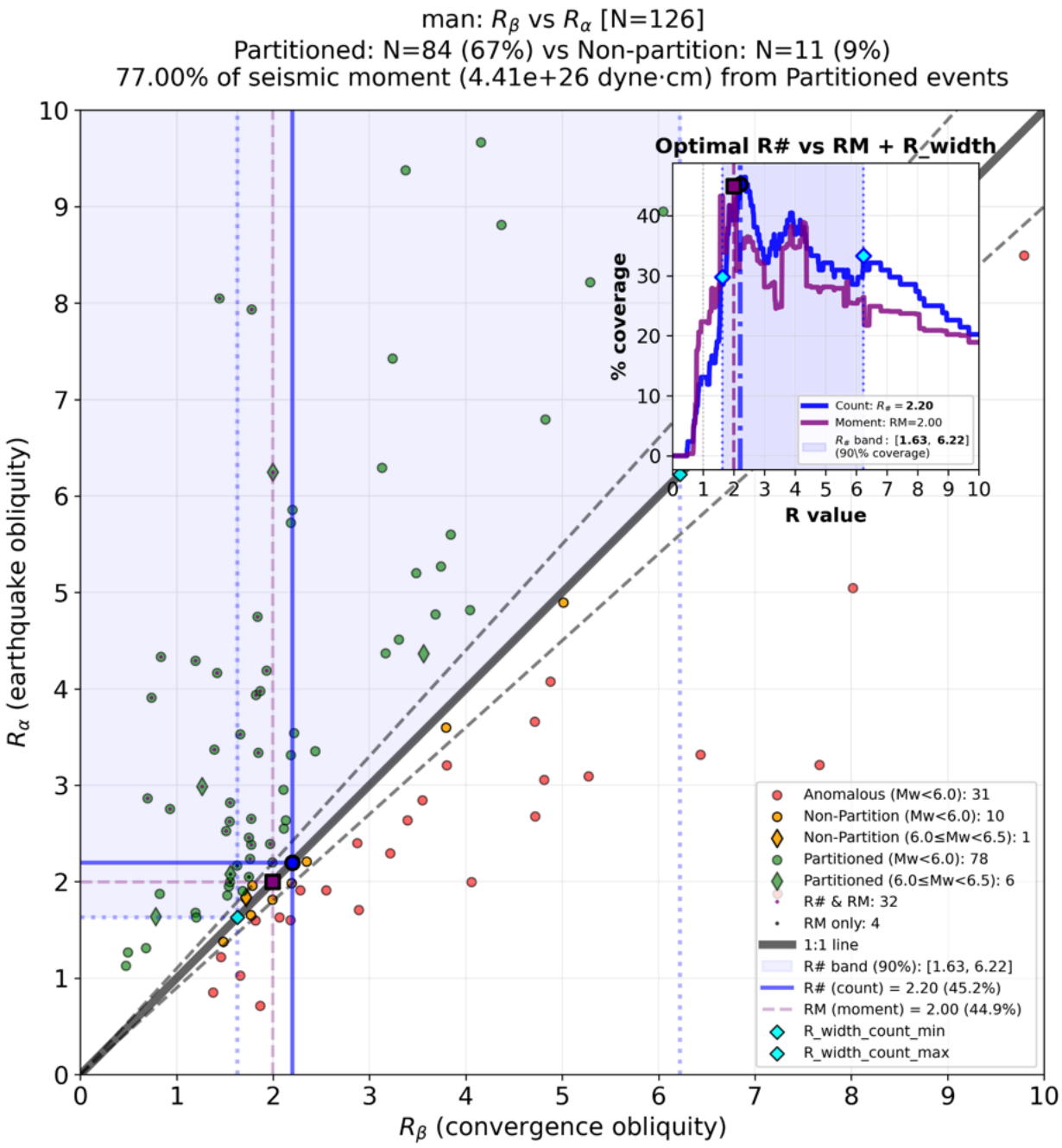


Fig. S-man-c. Manilla regime classification in Rβ-Rα space.

Normalized regime diagram showing partitioned, non-partitioned, and anomalous events, with R#, R_M, and R#90% interval. See Figure SX.c description.

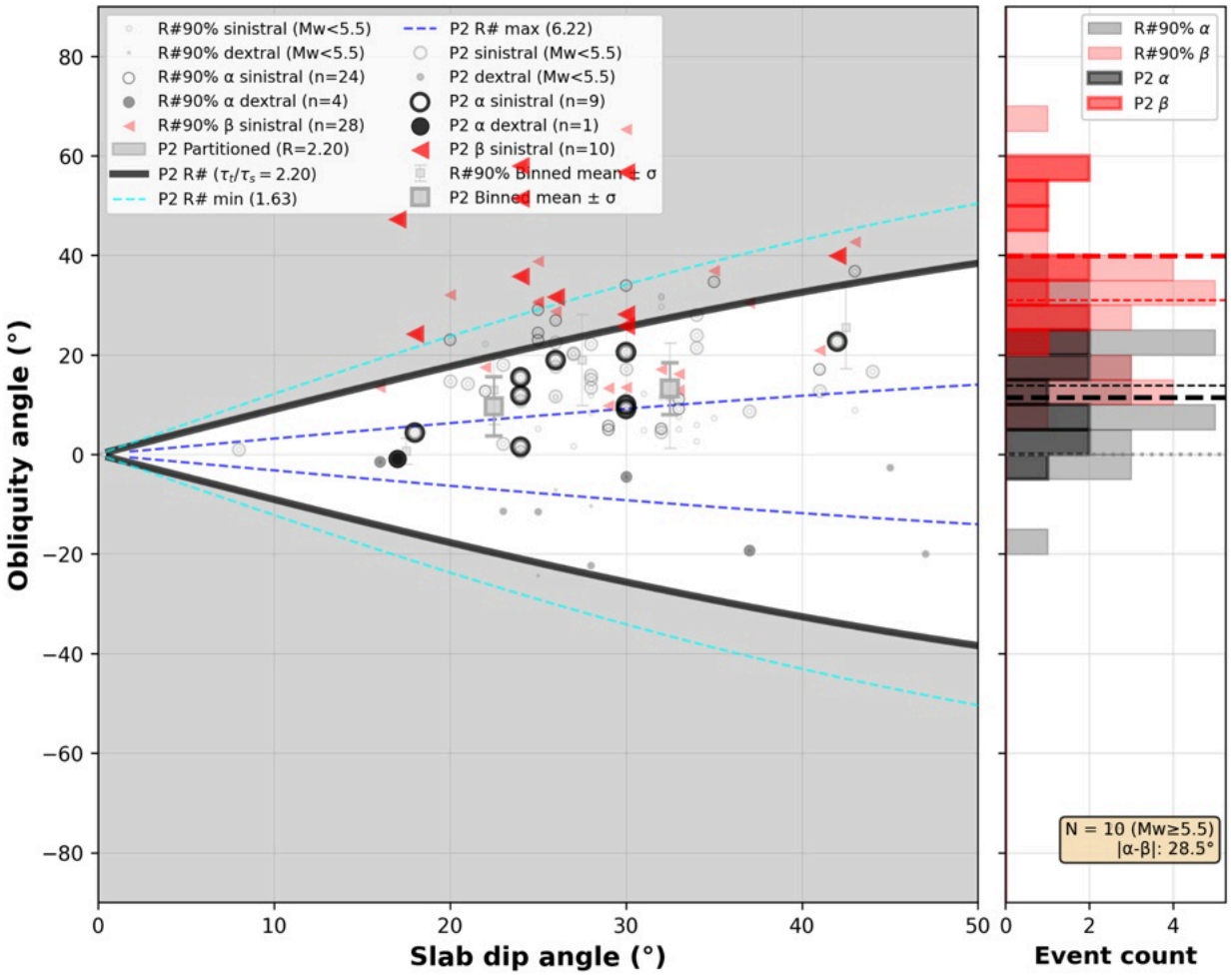


Fig. S-man-d. Manilla obliquity–dip comparison.

Earthquake slip obliquity and convergence obliquity plotted against slab dip, compared with analytic predictions. See Figure SX.d description.

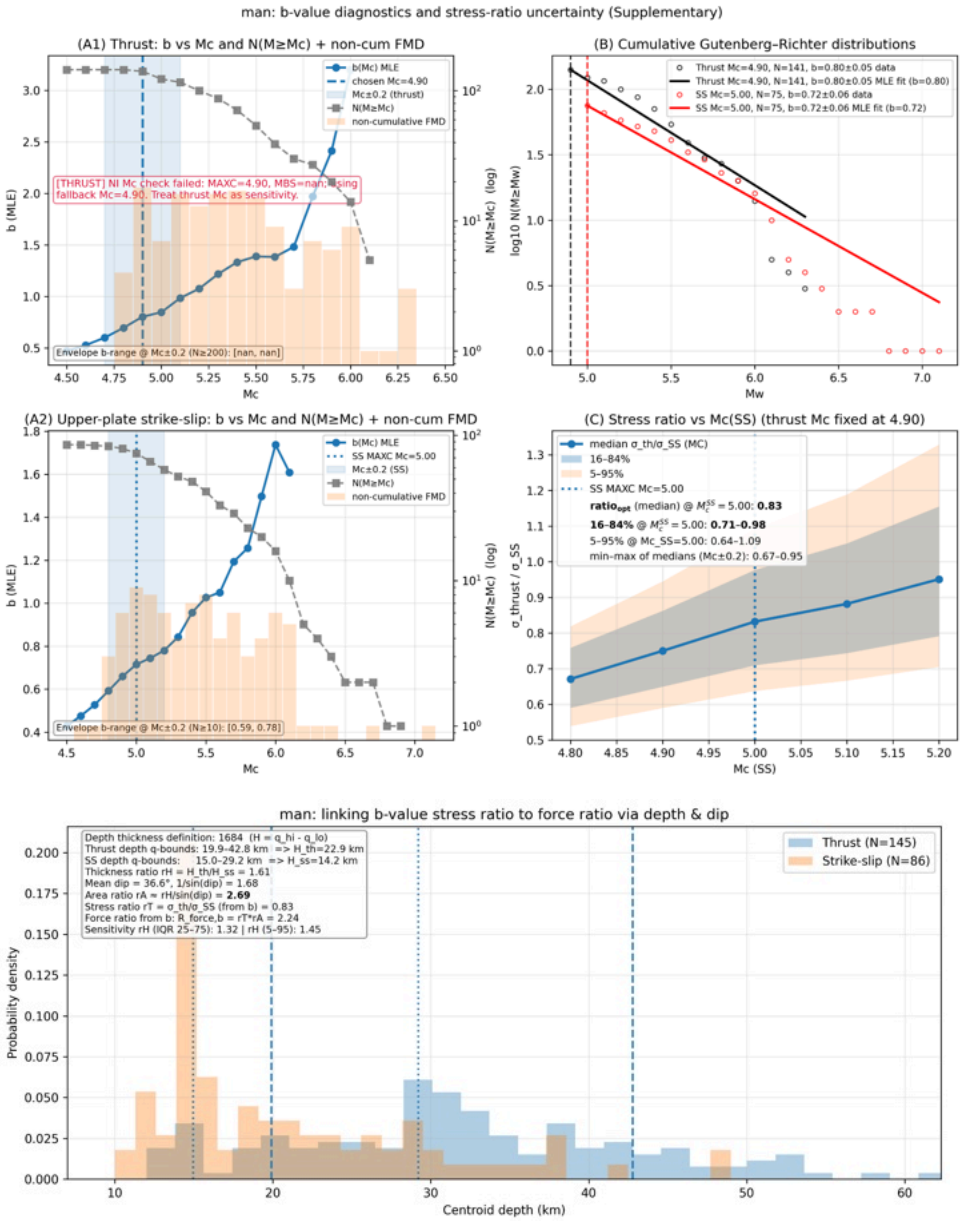


Fig. S-man-e. Manilla b-value stress-ratio estimate.

b-value and thrust-to–strike-slip stress-ratio estimates for the Manilla subduction zone. See Figure SX.e description.

8-phi:Philippines

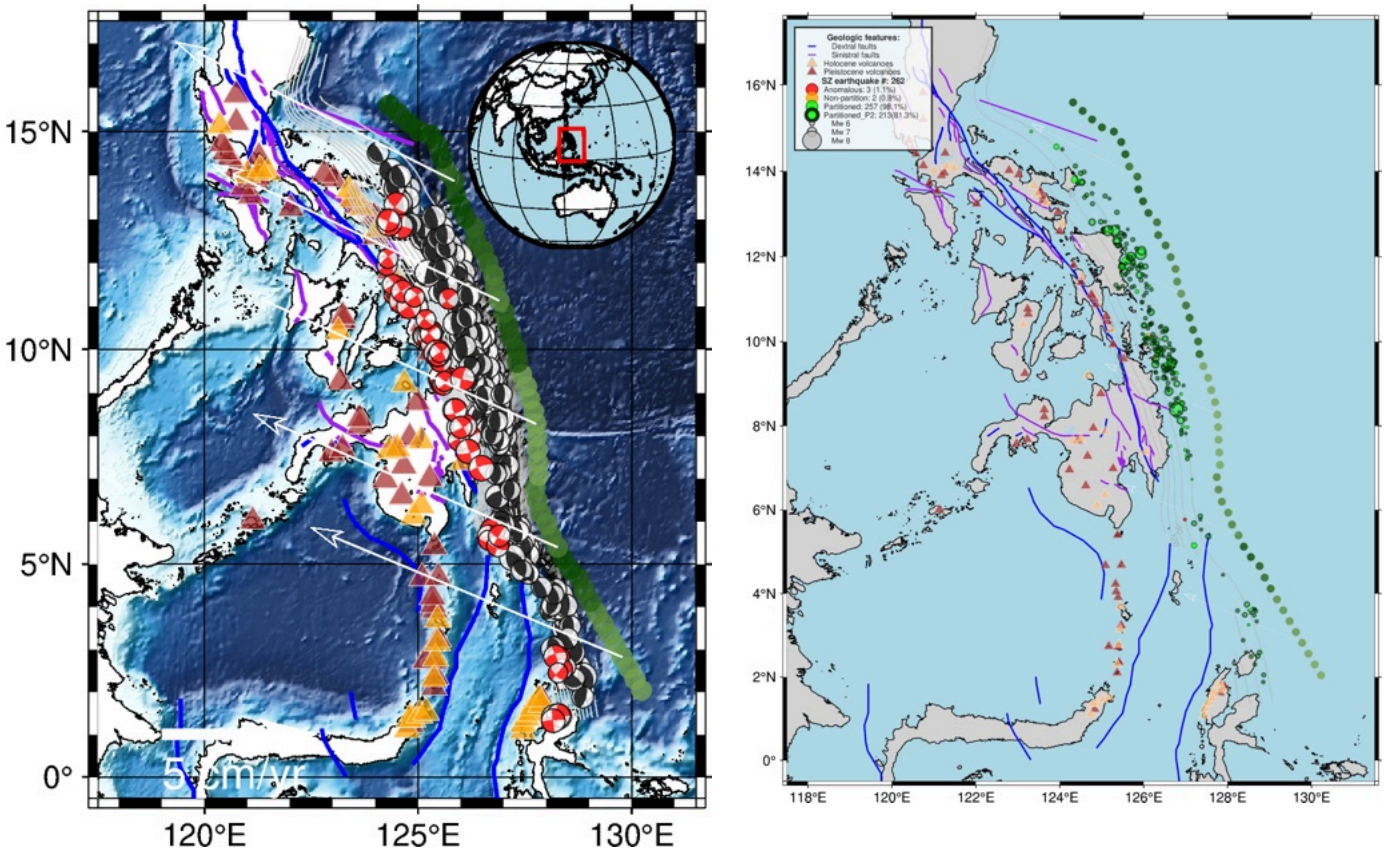


Fig. S-phi-a. Philippines tectonic setting and earthquake distribution.

Regional map and regime-colored earthquake distribution for the Philippines subduction zone. See Figure SX.a description for plotted quantities and symbol definitions.

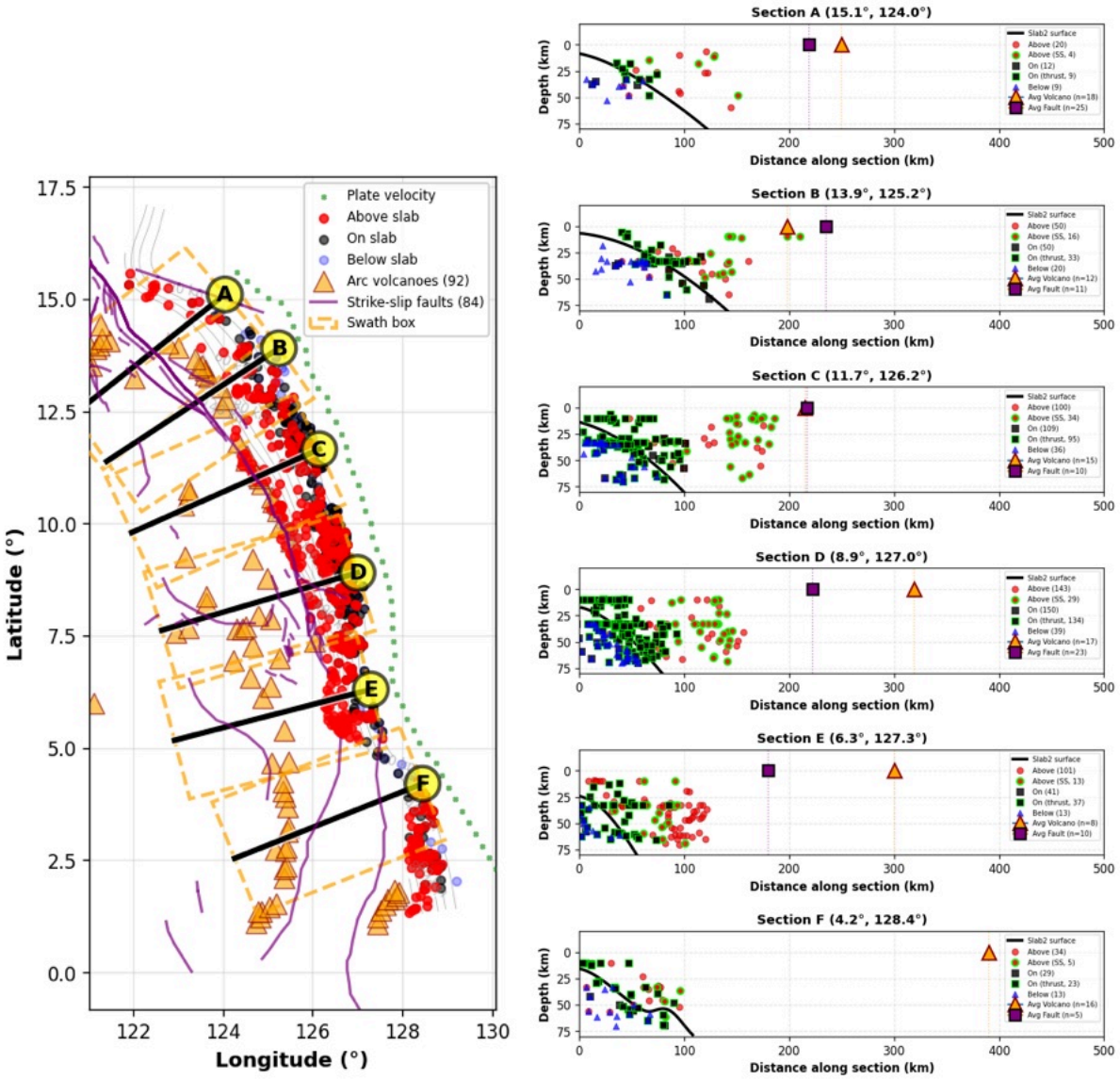


Fig. S-phi-b. Philippines seismicity relative to Slab2.

Map-view and trench-normal cross-sections showing earthquake distributions relative to the Slab2 interface. See Figure SX.b description.

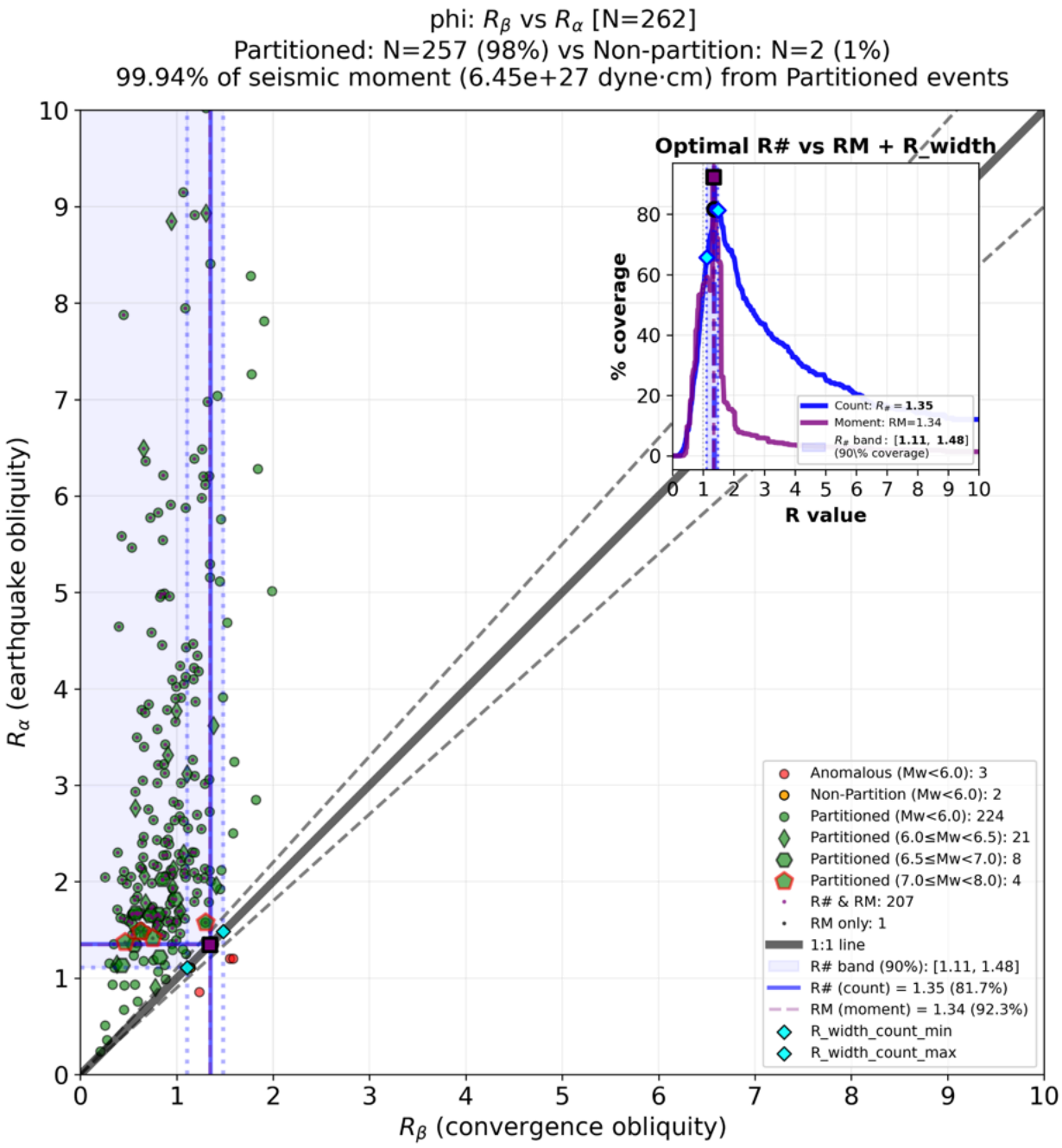


Fig. S-phi-c. Philippines regime classification in Rβ-Rα space.

Normalized regime diagram showing partitioned, non-partitioned, and anomalous events, with R#, R_M, and R#90% interval. See Figure SX.c description.

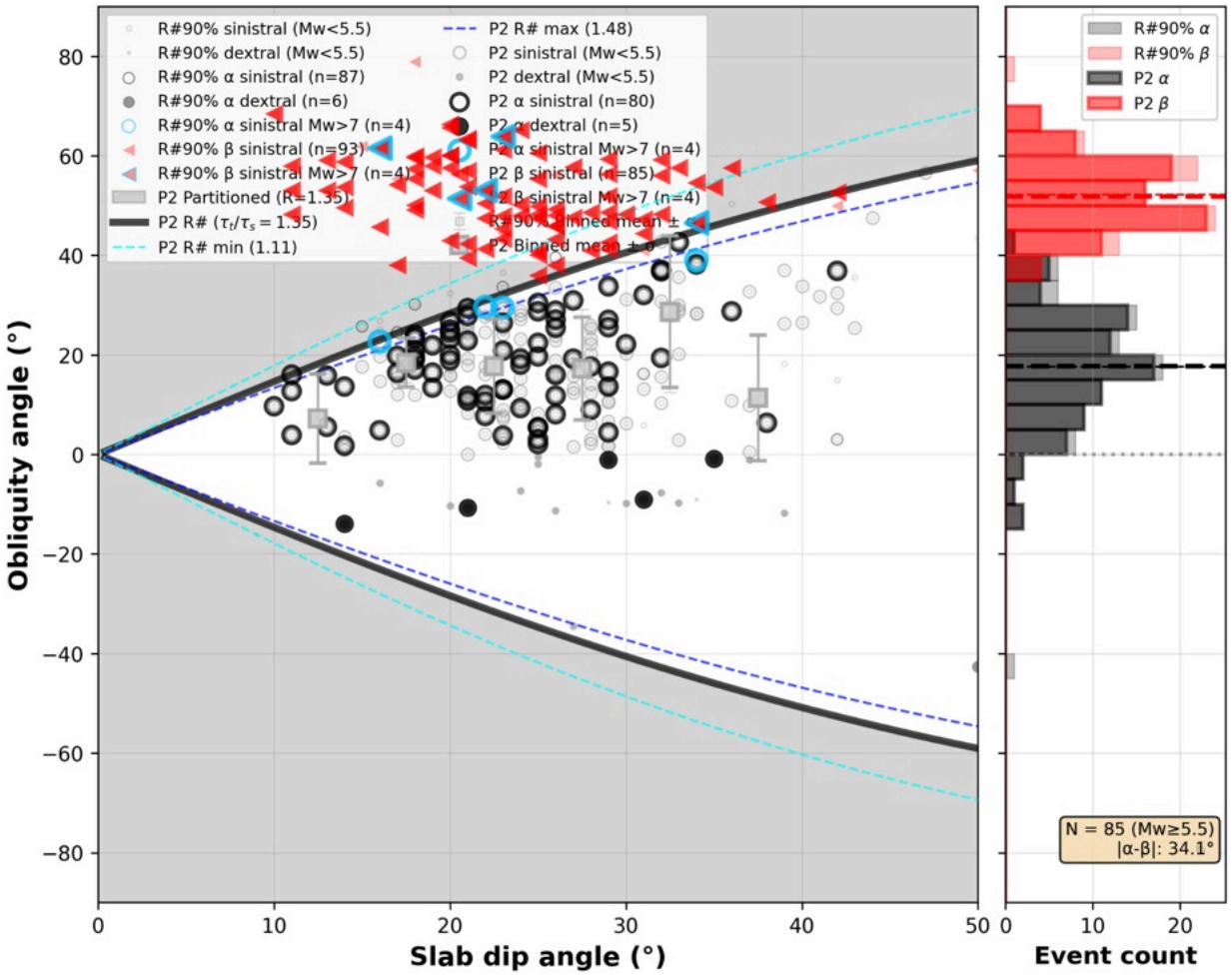


Fig. S-phi-d. Philippines obliquity–dip comparison.

Earthquake slip obliquity and convergence obliquity plotted against slab dip, compared with analytic predictions. See Figure SX.d description.

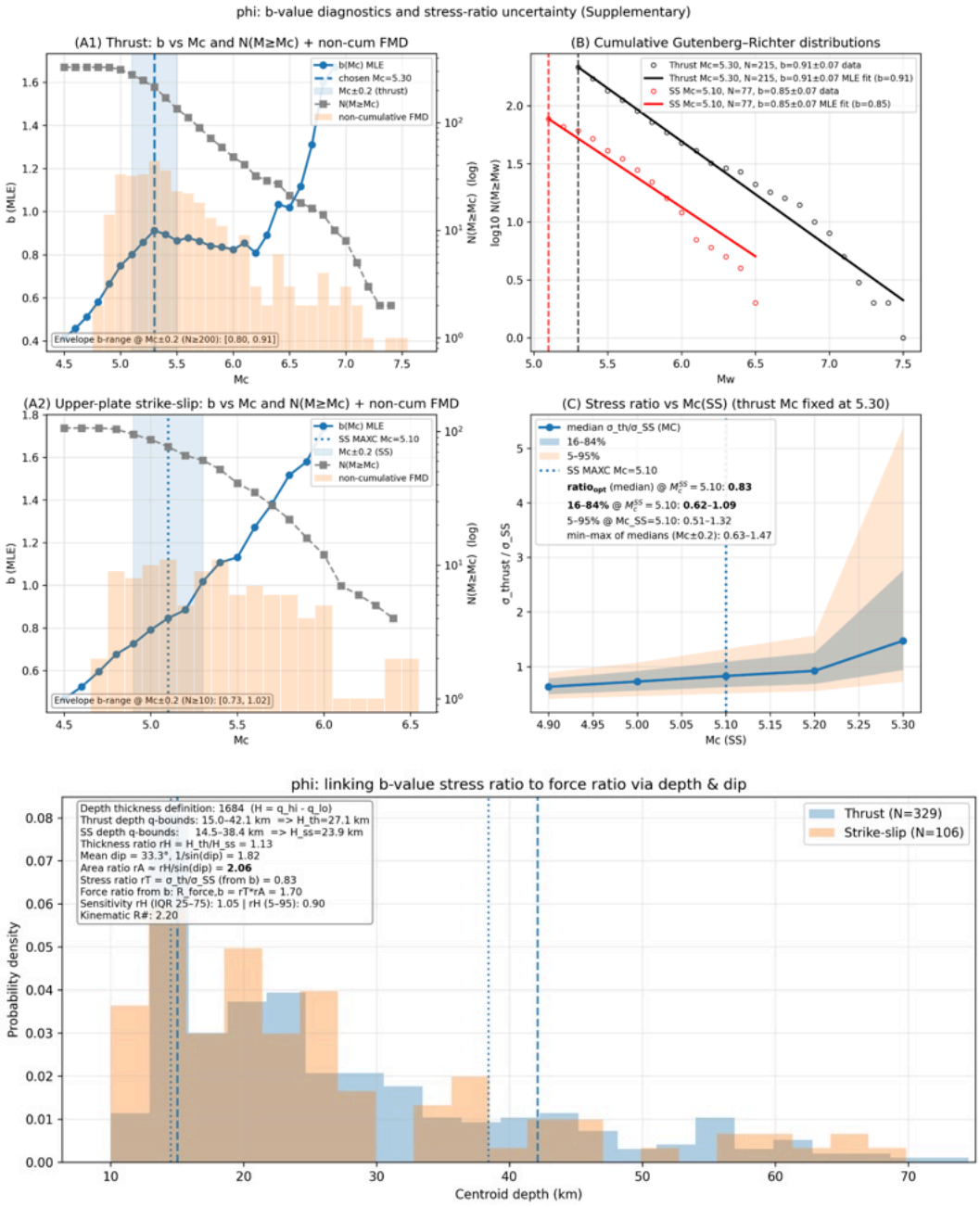


Fig. S-phi-e. Philippines b-value stress-ratio estimate.

b-value and thrust-to–strike-slip stress-ratio estimates for the Philippines subduction zone. See Figure SX.e description.

9-ryu:Ryuku Nankai

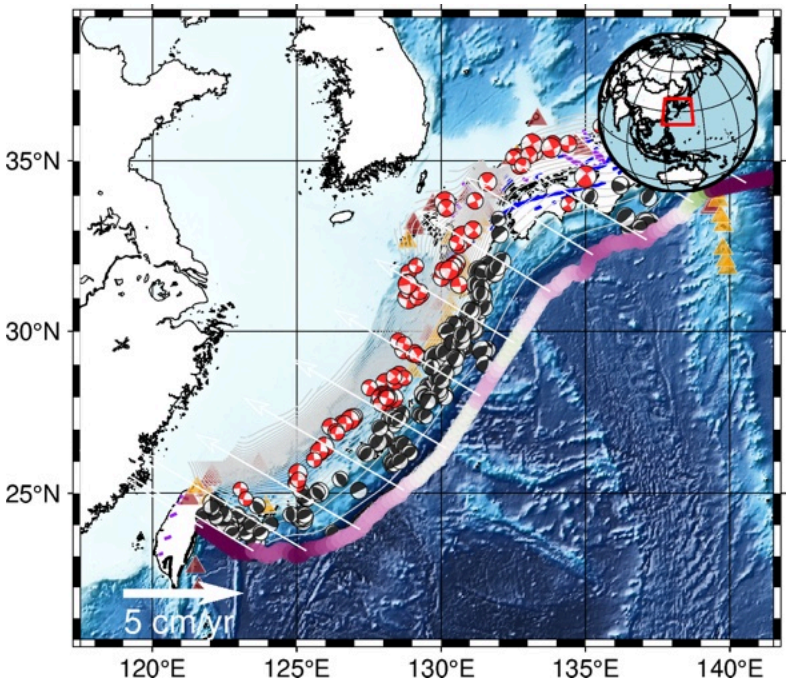
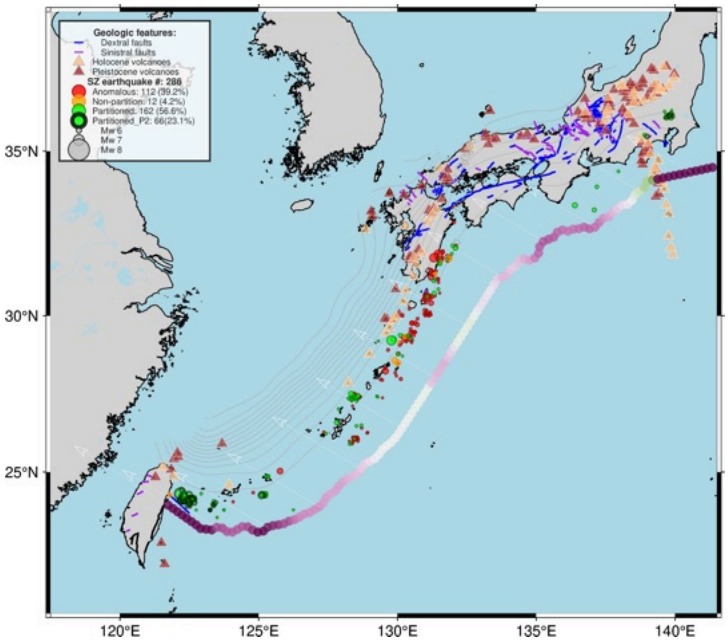
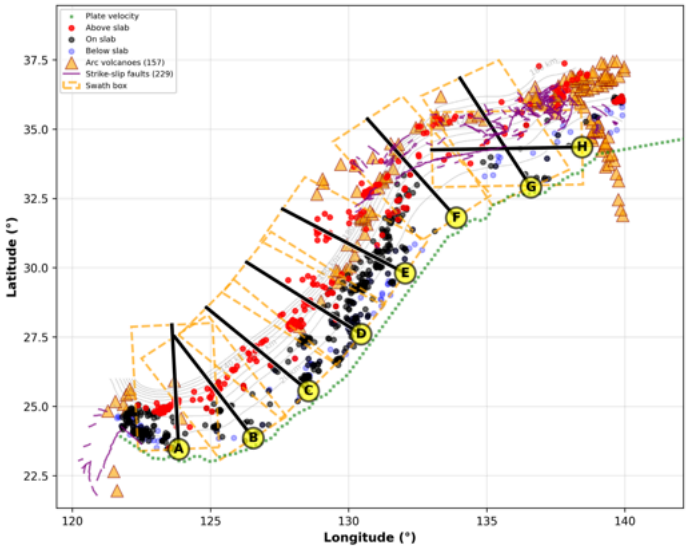


Fig. S-ryu-a. Ryuku-Nankai tectonic setting and earthquake distribution.

Regional map and regime-colored earthquake distribution for the Ryuku-Nankai subduction zone. See Figure SX.a description for plotted quantities and symbol definitions.





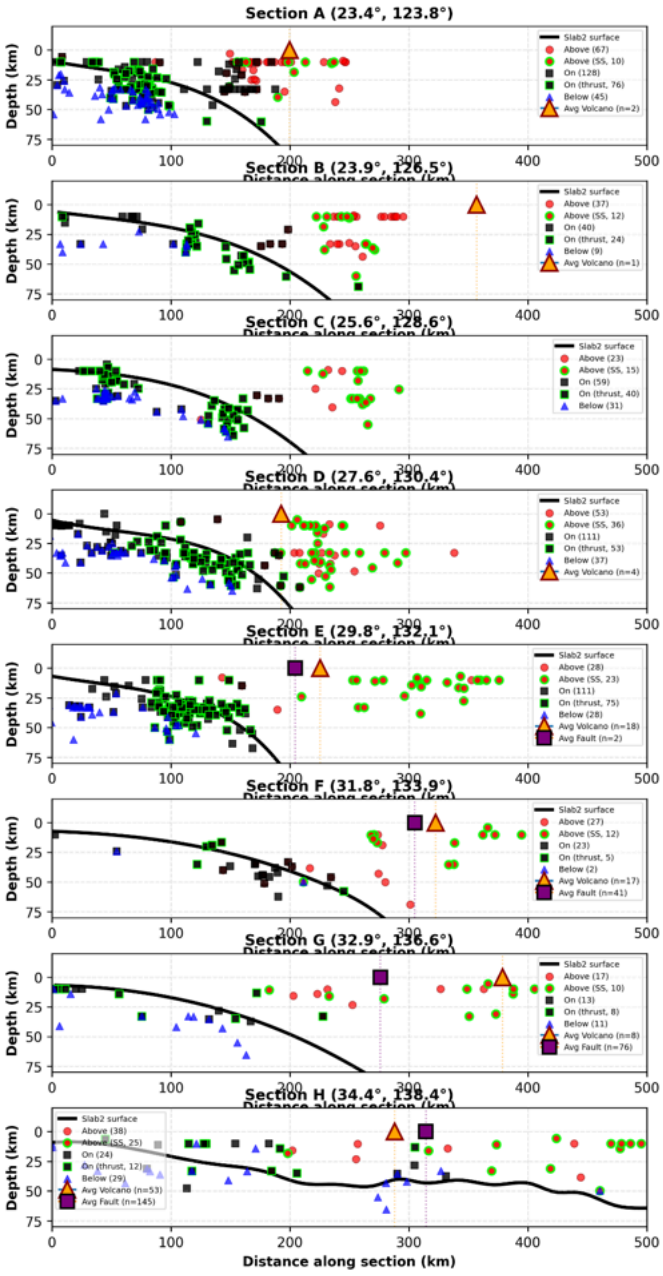


Fig. S-ryu-b. Ryuku-Nankai seismicity relative to Slab2.

Map-view and trench-normal cross-sections showing earthquake distributions relative to the Slab2 interface. See Figure SX.b description.

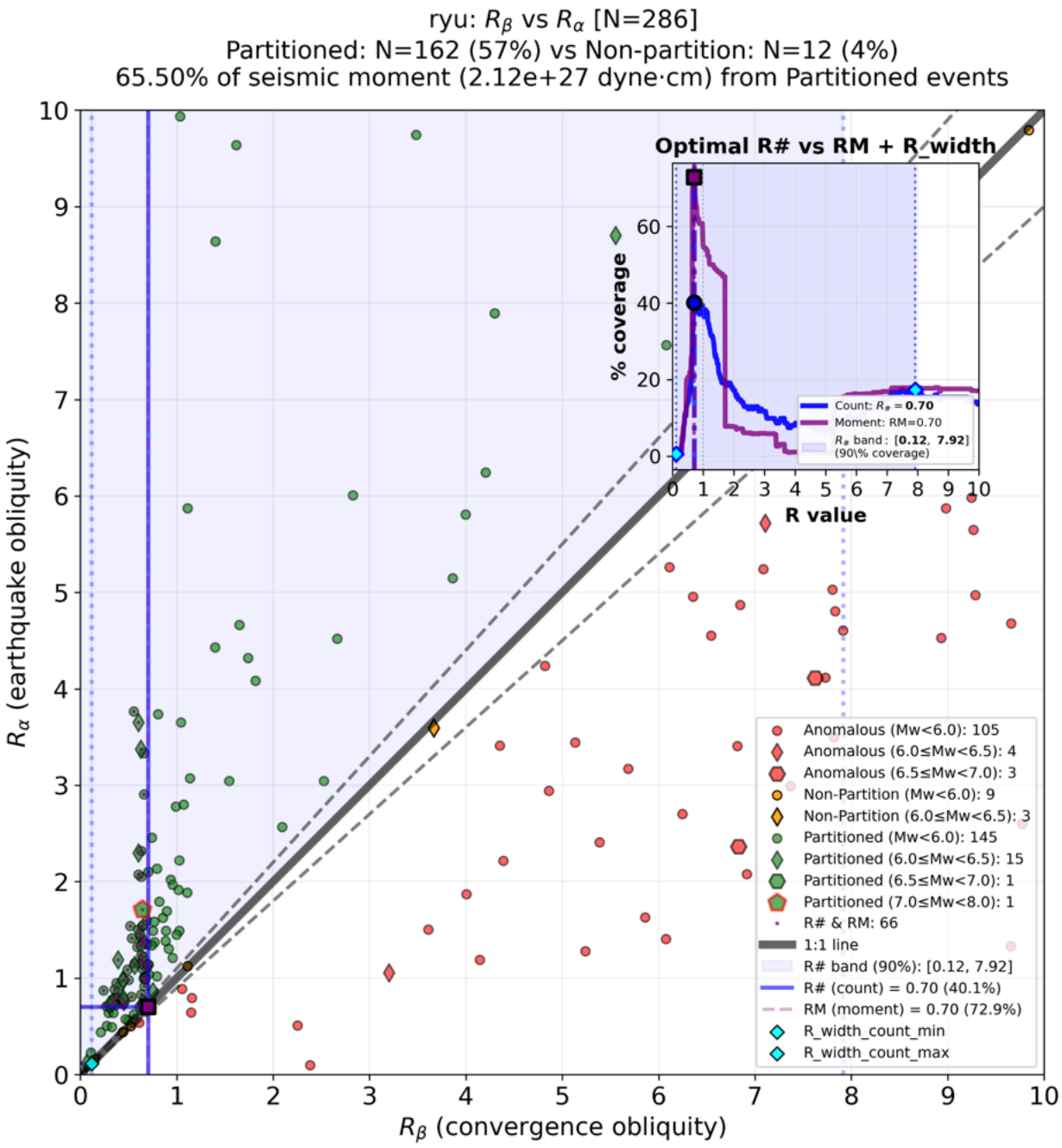


Fig. S-ryu-c. Ryuku-Nankai regime classification in Rβ-Rα space.

Normalized regime diagram showing partitioned, non-partitioned, and anomalous events, with R#, R_M, and R#90% interval. See Figure SX.c description.

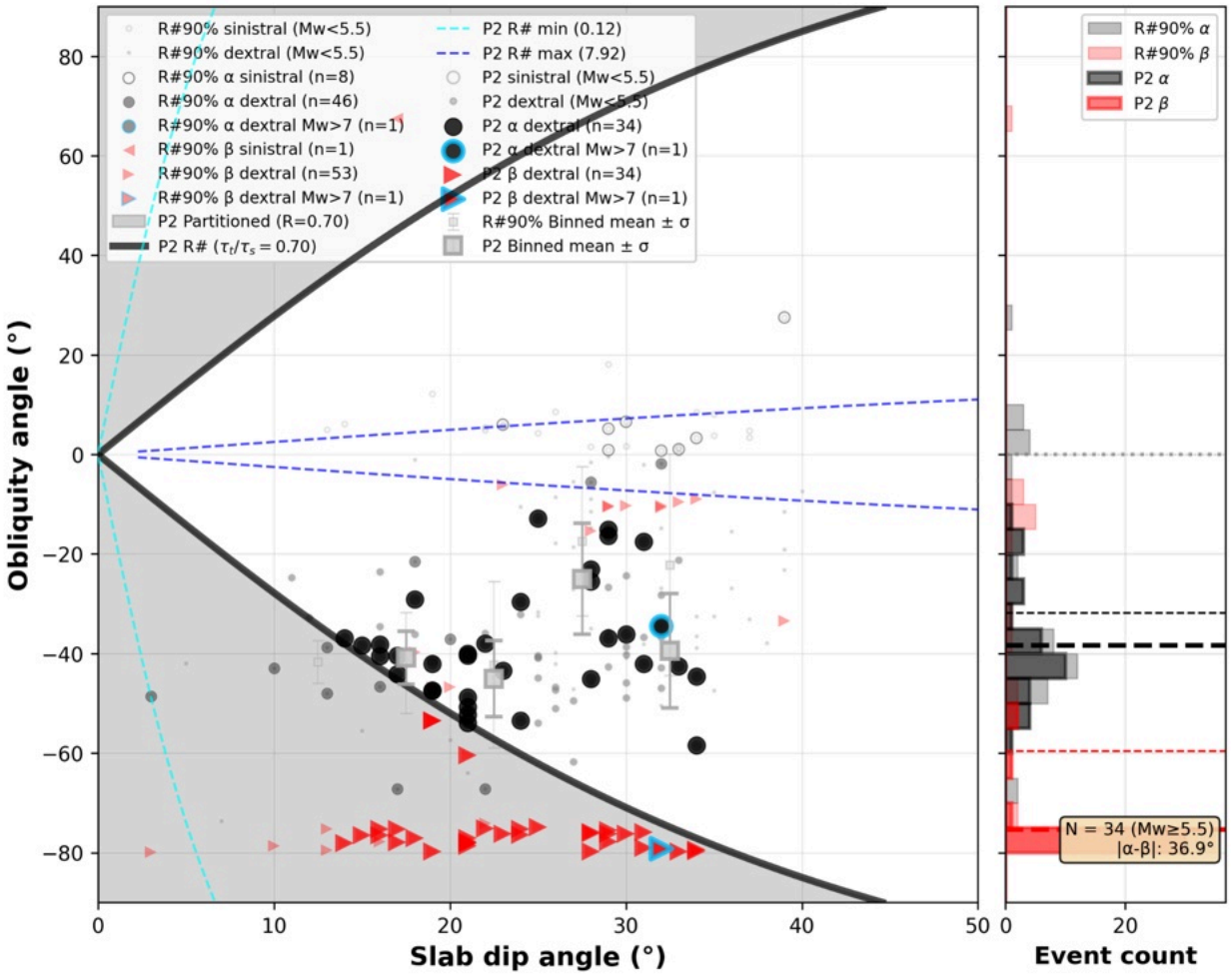


Fig. S-ryu-d. Ryuku-Nankai obliquity–dip comparison.

Earthquake slip obliquity and convergence obliquity plotted against slab dip, compared with analytic predictions. See Figure SX.d description.

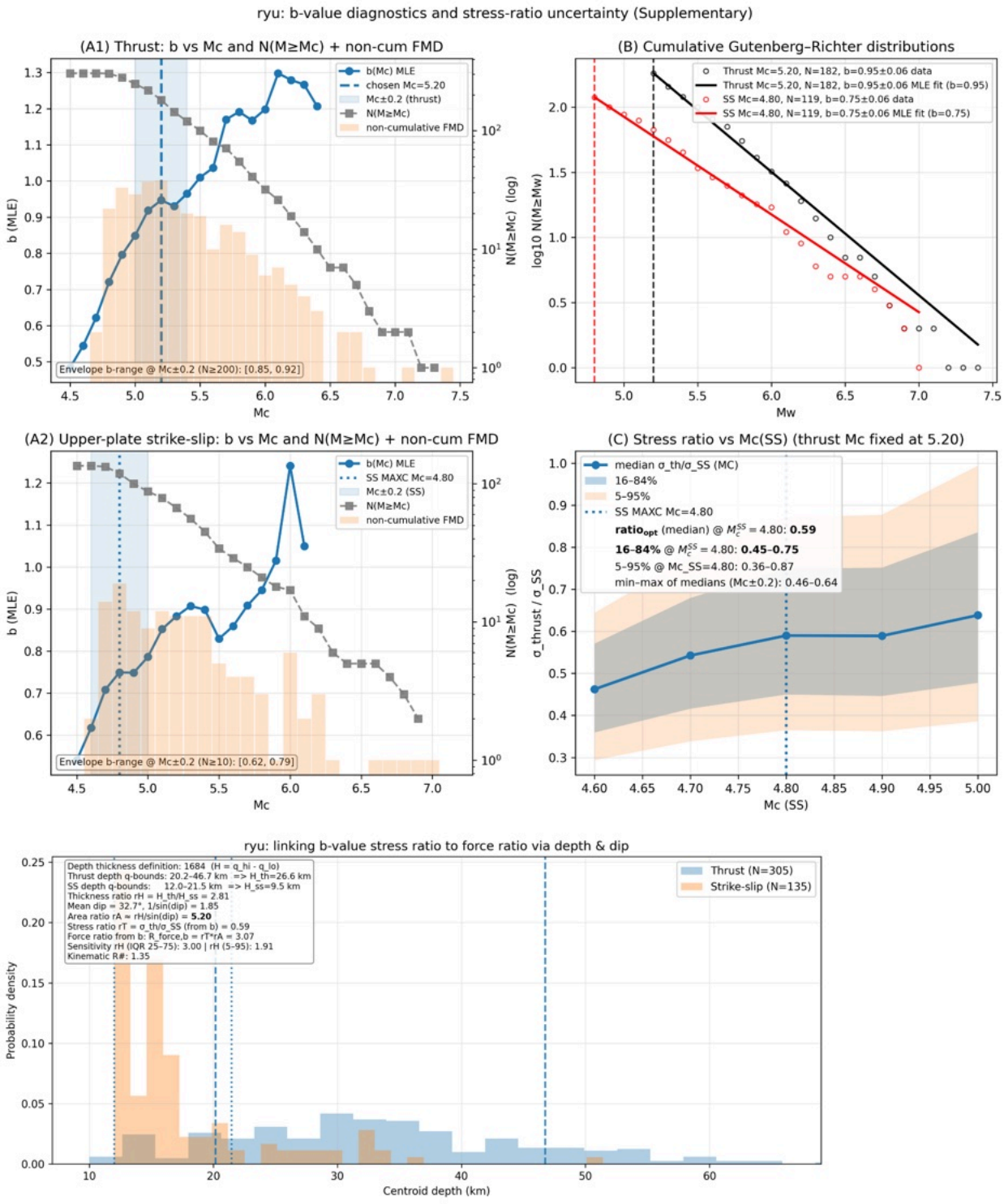


Fig. S-ryu-e. Ryuku-Nankai b-value stress-ratio estimate.

b-value and thrust-to–strike-slip stress-ratio estimates for the Ryuku-Nankai subduction zone. See Figure SX.e description.

10-sam:South America

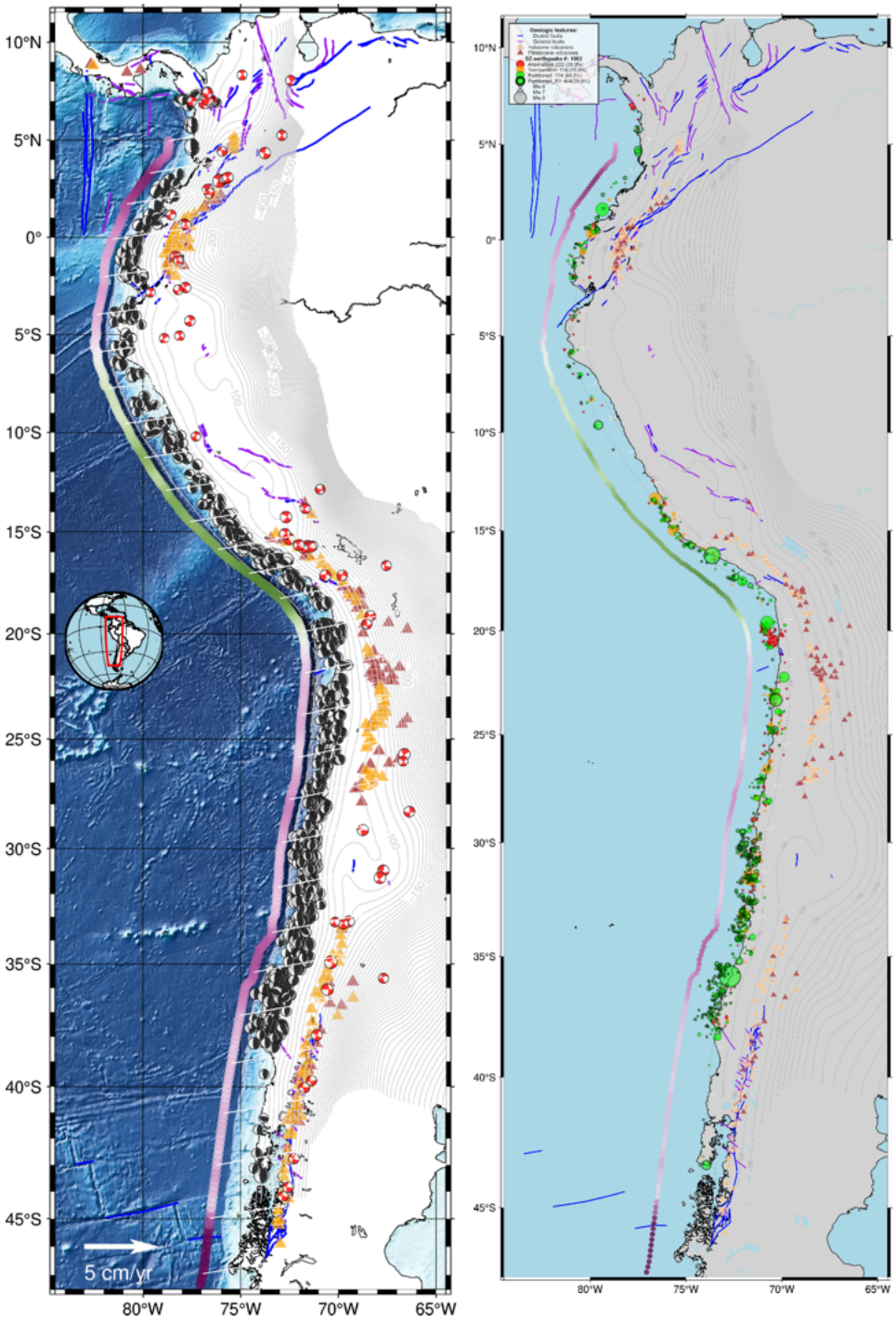


Fig. S-sam-a. South America tectonic setting and earthquake distribution.

Regional map and regime-colored earthquake distribution for the South America subduction zone. See Figure SX.a description for plotted quantities and symbol definitions.

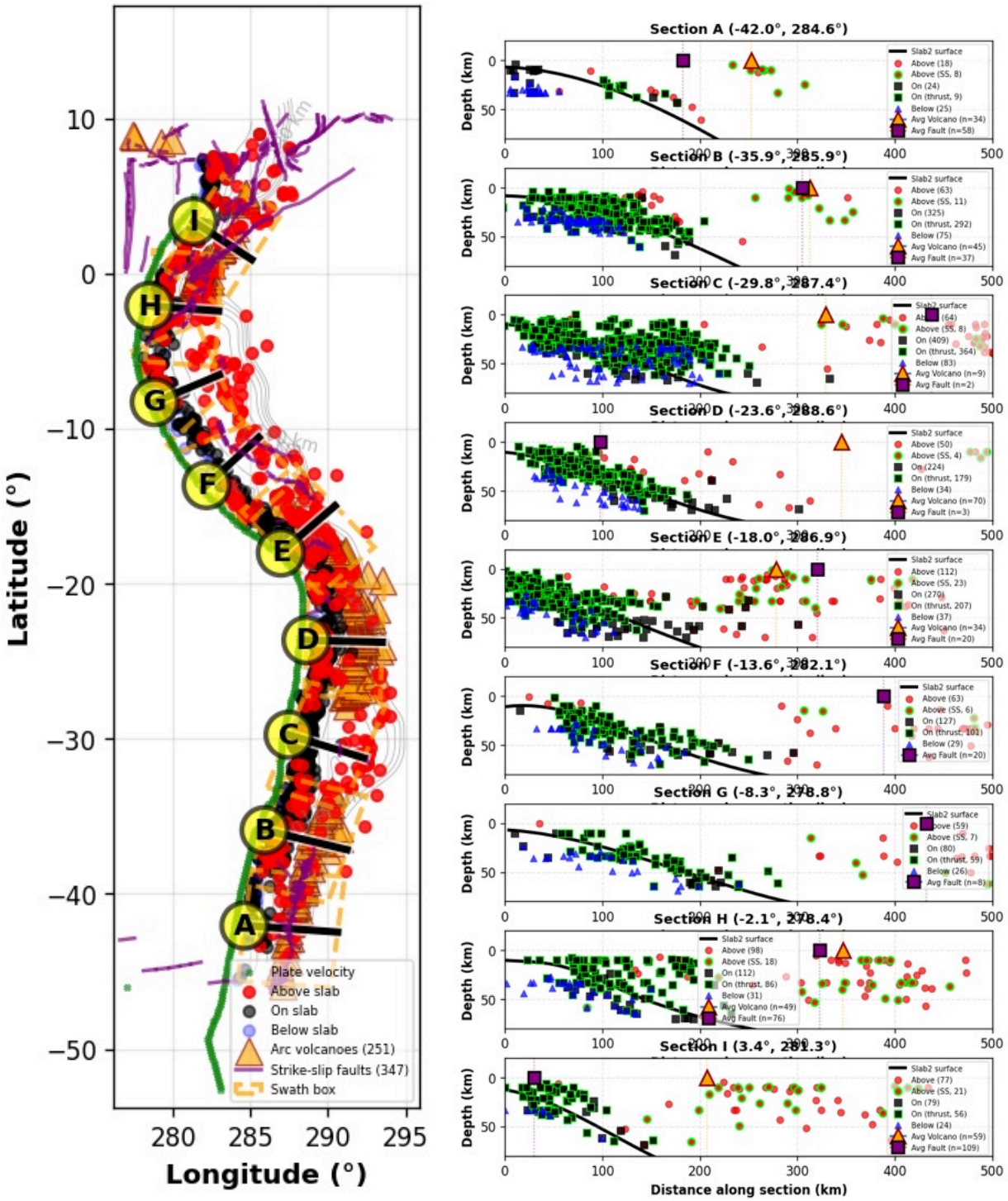


Fig. S-sam-b. South America seismicity relative to Slab2.

Map-view and trench-normal cross-sections showing earthquake distributions relative to the Slab2 interface. See Figure SX.b description.

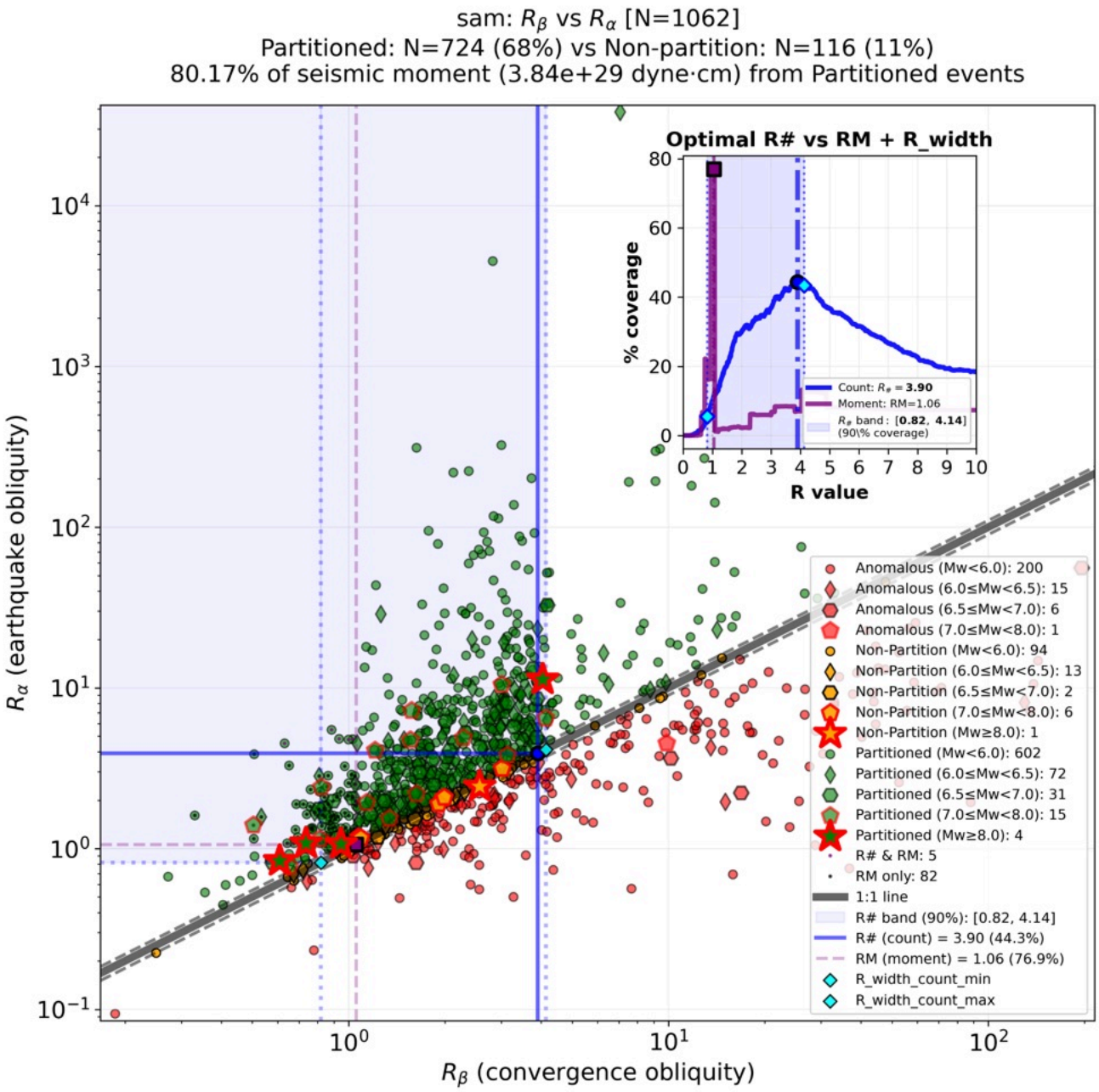


Fig. S-sam-c. South America regime classification in Rβ-Rα space.

Normalized regime diagram showing partitioned, non-partitioned, and anomalous events, with R#, R_M, and R#90% interval. See Figure SX.c description.

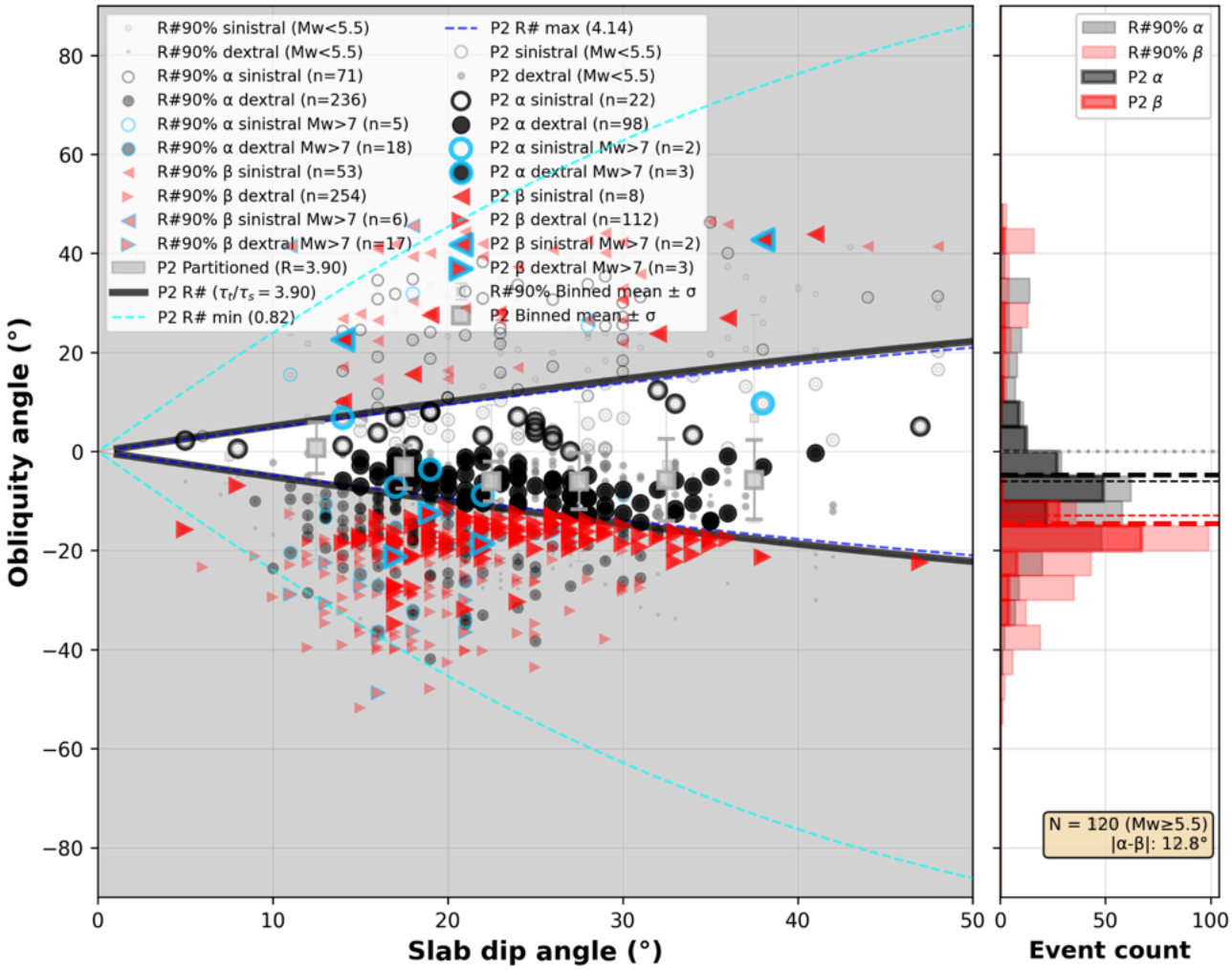


Fig. S-sam-d. South America obliquity–dip comparison.

Earthquake slip obliquity and convergence obliquity plotted against slab dip, compared with analytic predictions. See Figure SX.d description.

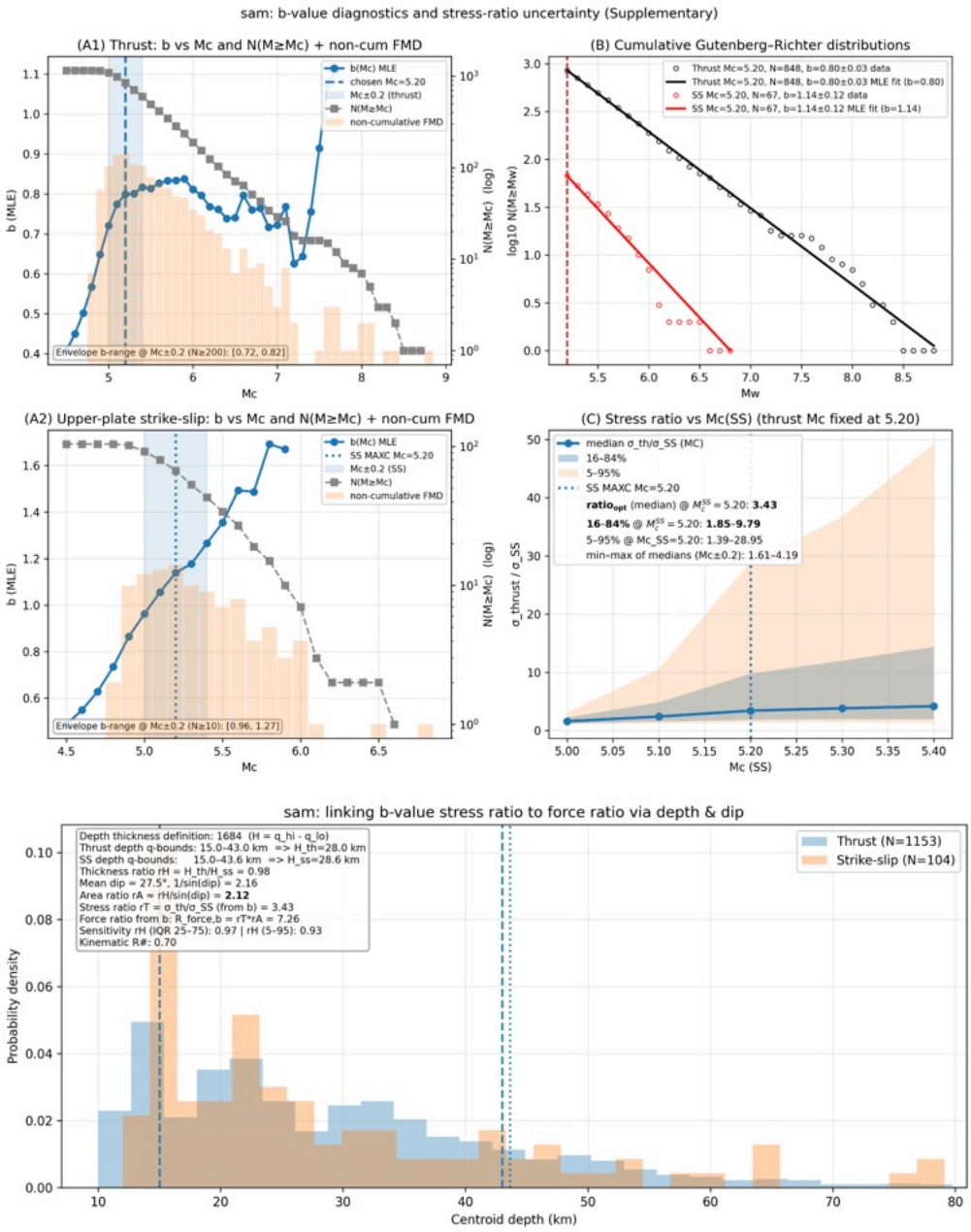


Fig. S-sam-e. South America b-value stress-ratio estimate.

b-value and thrust-to–strike-slip stress-ratio estimates for the South America subduction zone. See Figure SX.e description.

11-sco:Scotia

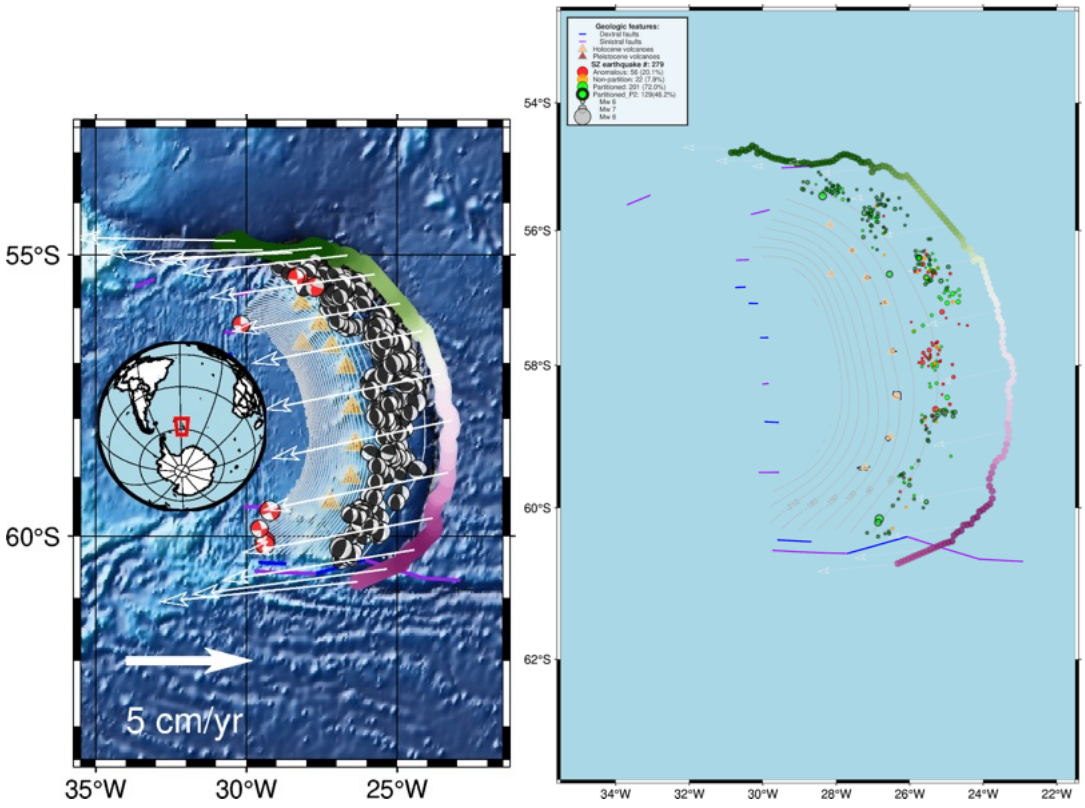


Fig. S-sco-a. Scotia tectonic setting and earthquake distribution.

Regional map and regime-colored earthquake distribution for the Scotia subduction zone. See Figure SX.a description for plotted quantities and symbol definitions.

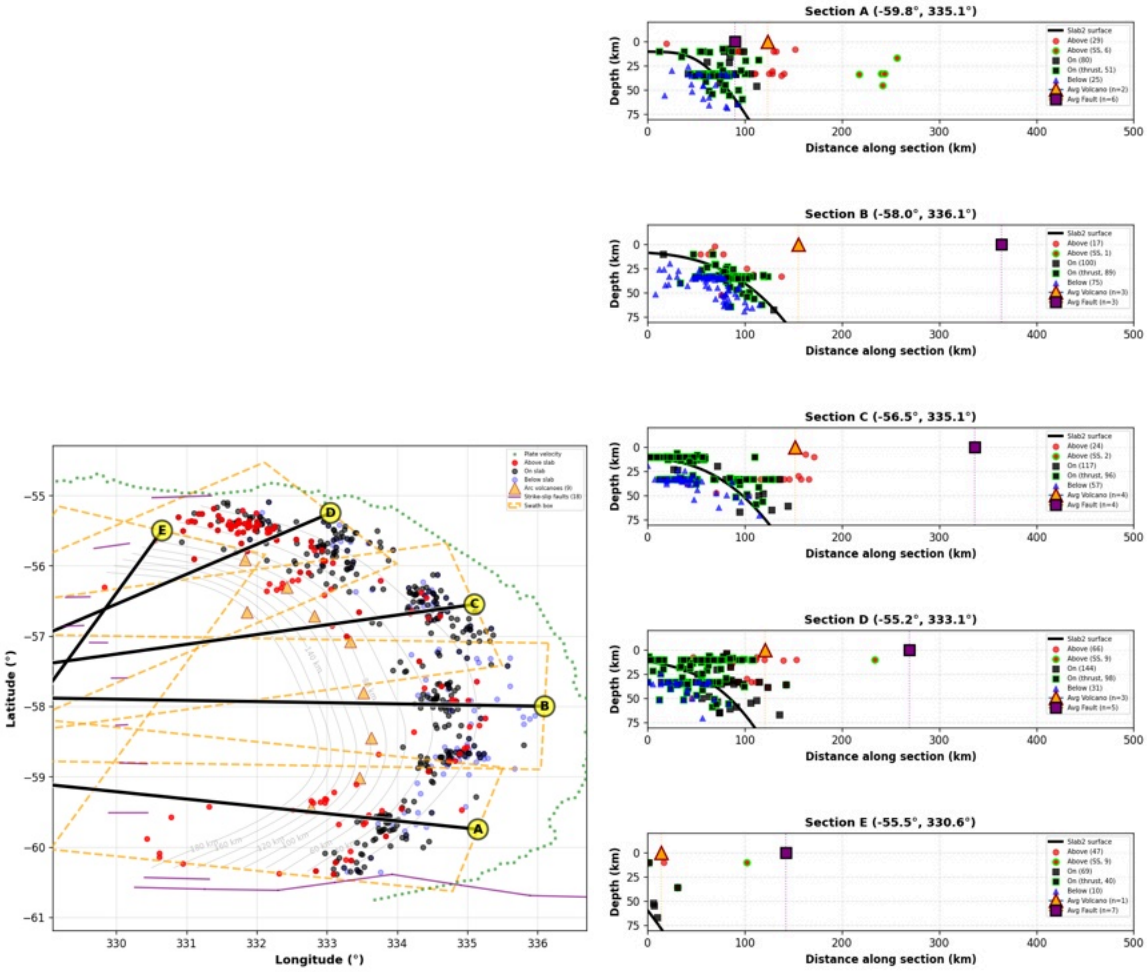


Fig. S-sco-b. Scotia seismicity relative to Slab2.

Map-view and trench-normal cross-sections showing earthquake distributions relative to the Slab2 interface. See Figure SX.b description.

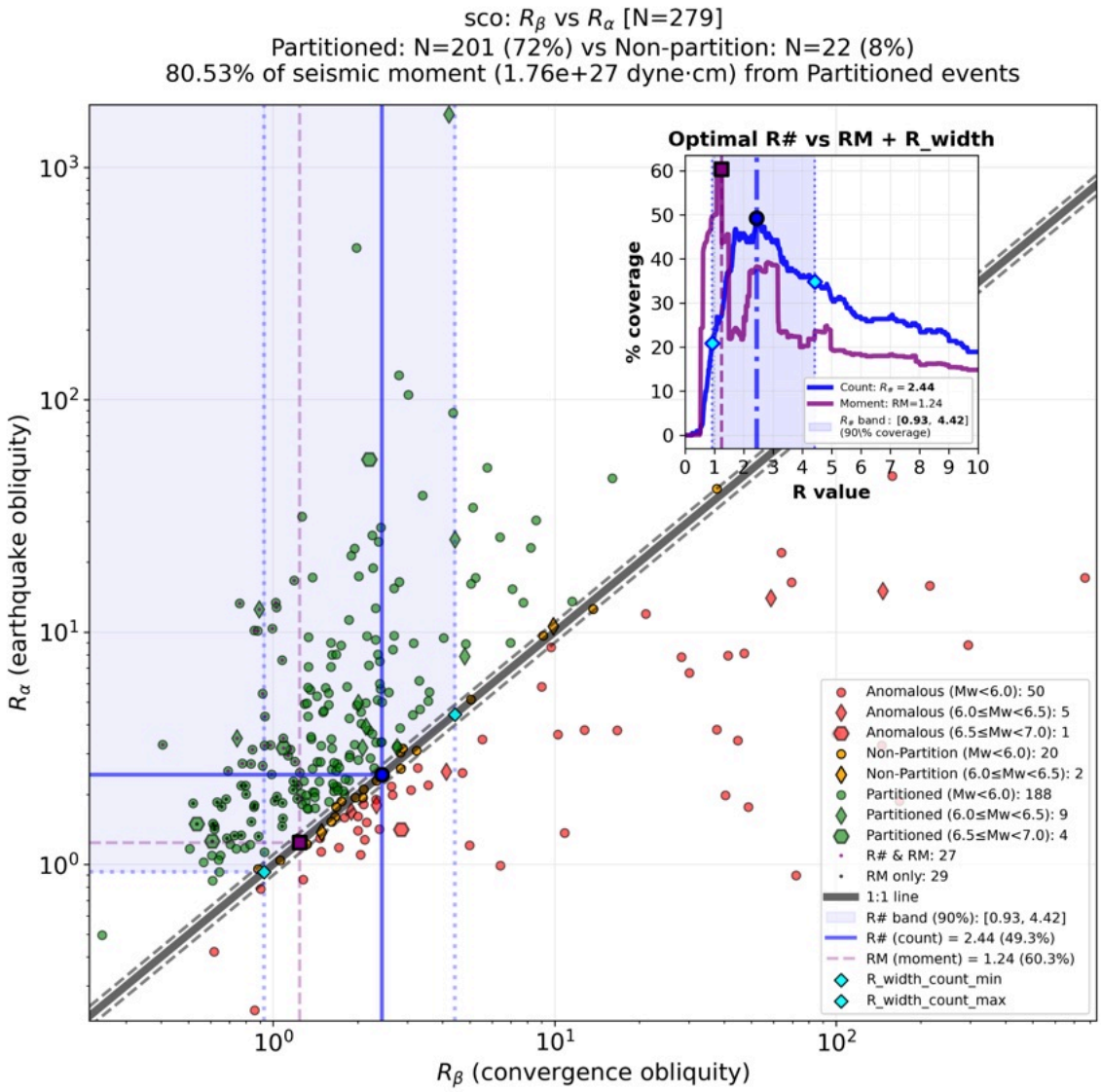


Fig. S-sco-c. Scotia regime classification in Rβ-Rα space.

Normalized regime diagram showing partitioned, non-partitioned, and anomalous events, with R#, R_M, and R#90% interval. See Figure SX.c description.

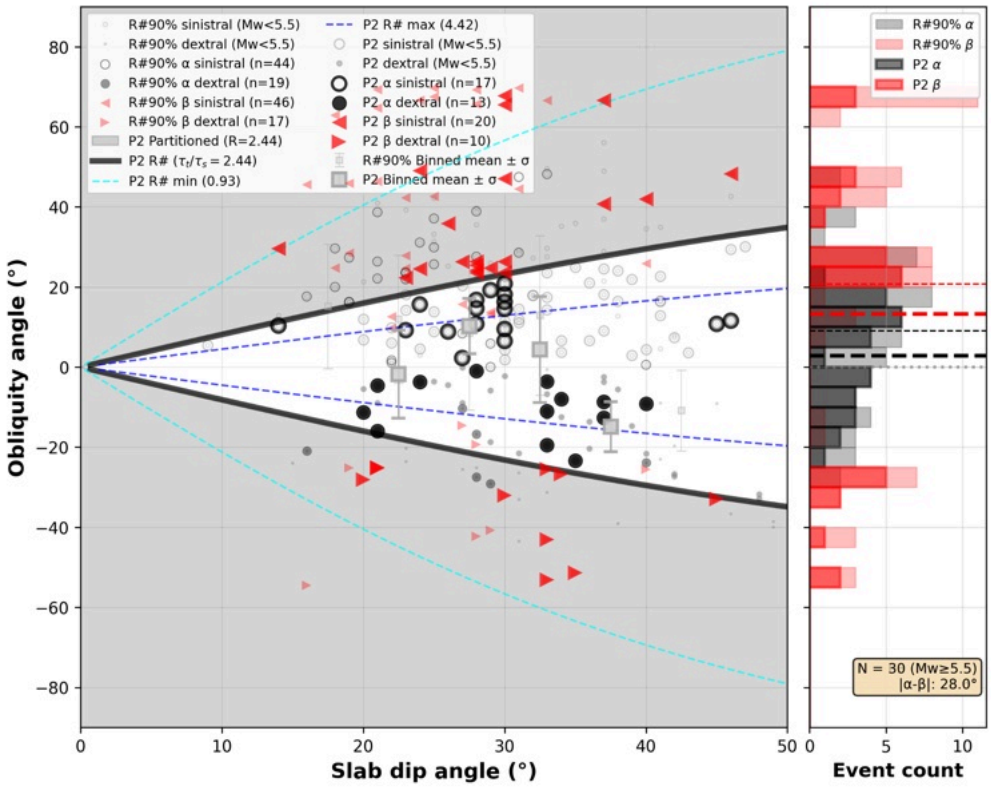


Fig. S-sco-d. Scotia obliquity–dip comparison.

Earthquake slip obliquity and convergence obliquity plotted against slab dip, compared with analytic predictions. See Figure SX.d description.

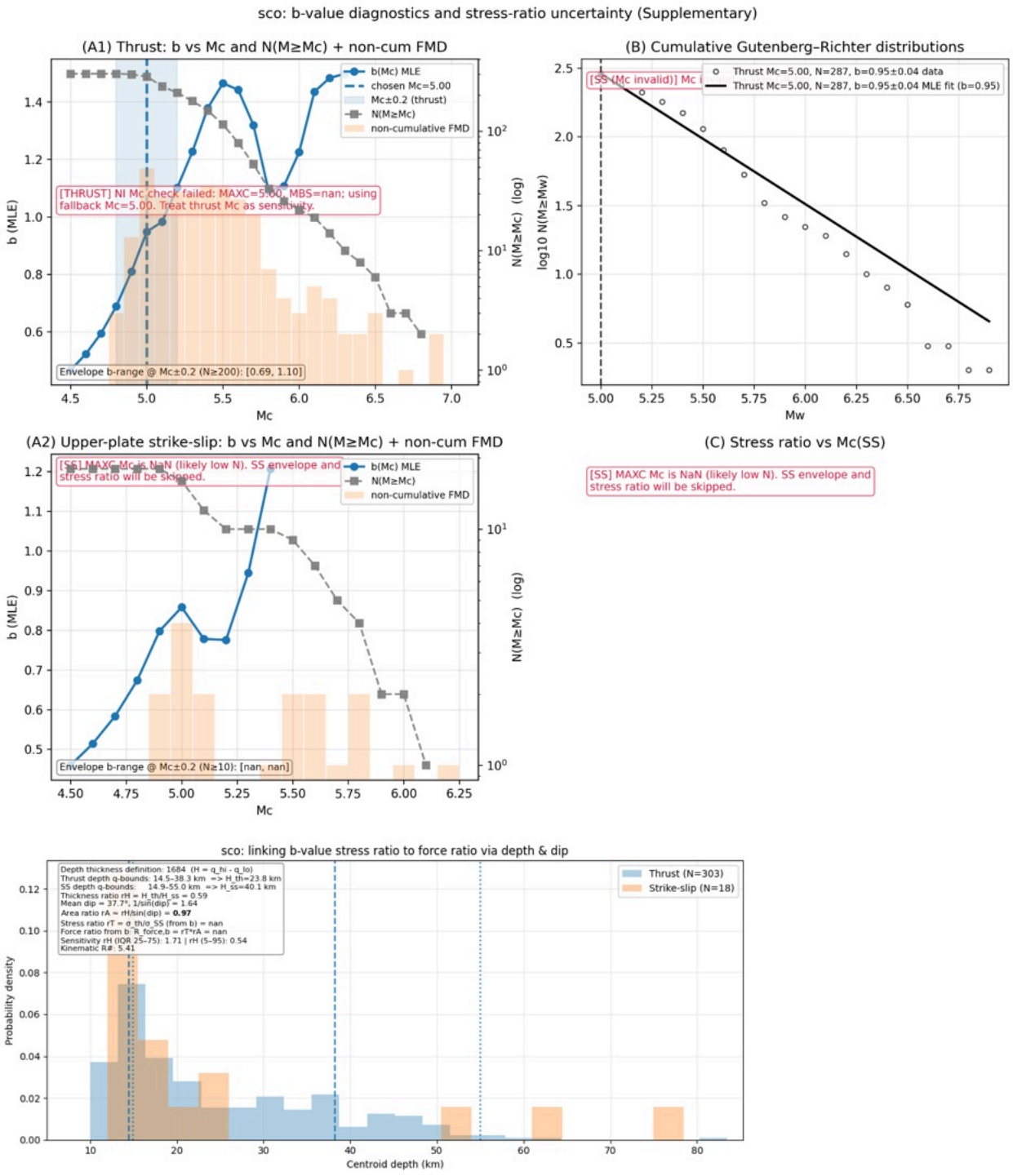


Fig. S-sco-e. Scotia b-value stress-ratio estimate.

b-value and thrust-to–strike-slip stress-ratio estimates for the Scotia subduction zone. See Figure SX.e description.

12-sol:Solomons

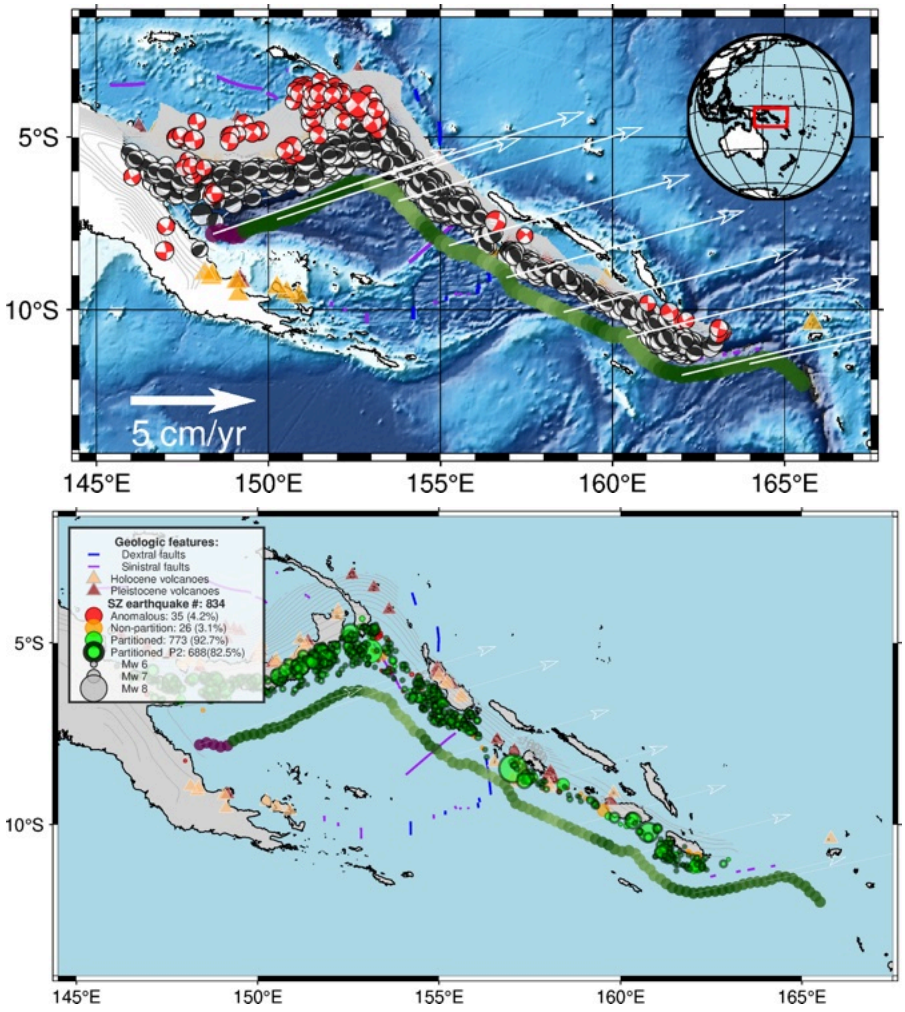


Fig. S-sol-a. Solomons tectonic setting and earthquake distribution.

Regional map and regime-colored earthquake distribution for the Solomons subduction zone. See Figure SX.a description for plotted quantities and symbol definitions.

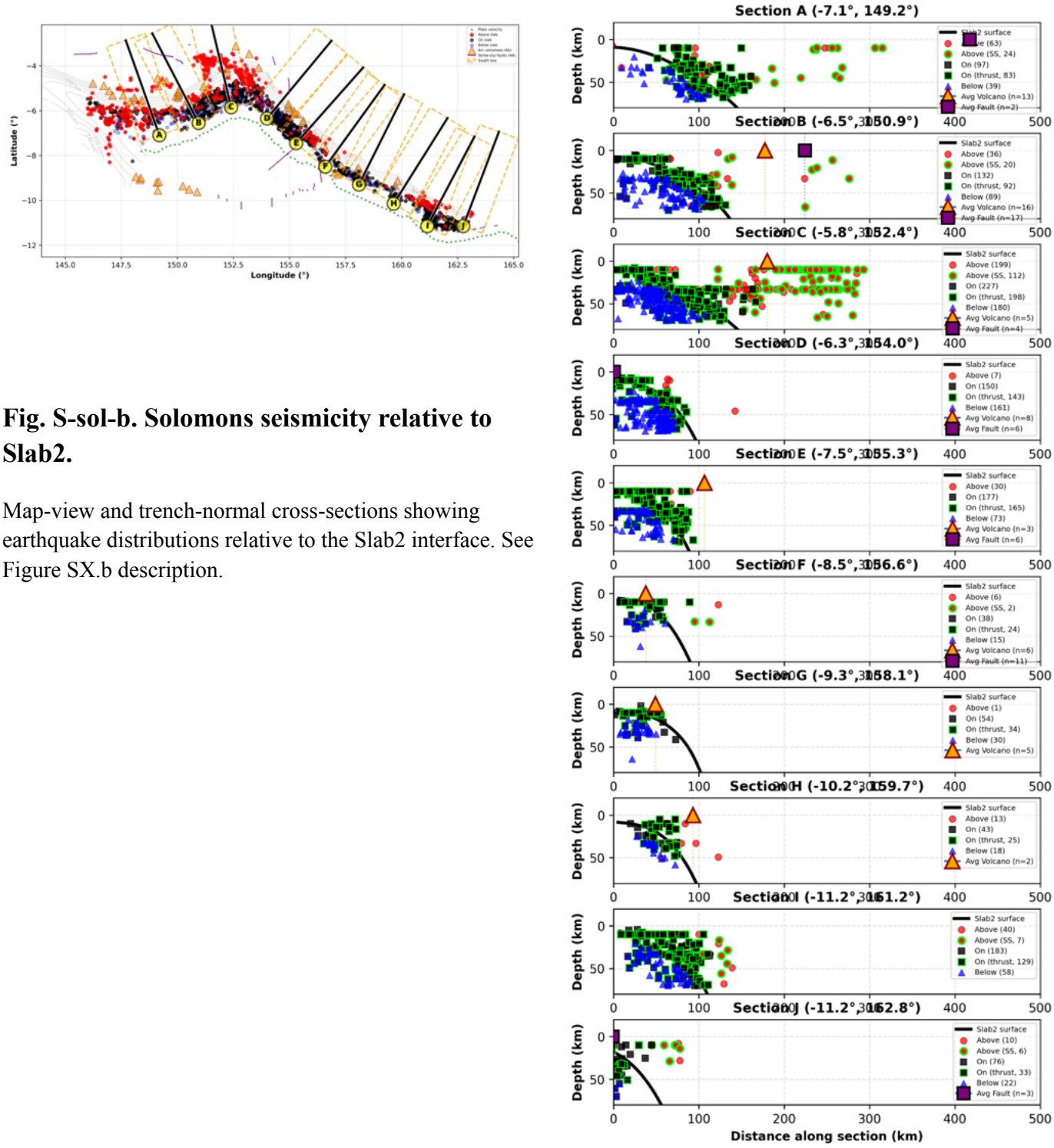


Fig. S-sol-b. Solomons seismicity relative to Slab2.

Map-view and trench-normal cross-sections showing earthquake distributions relative to the Slab2 interface. See Figure SX.b description.

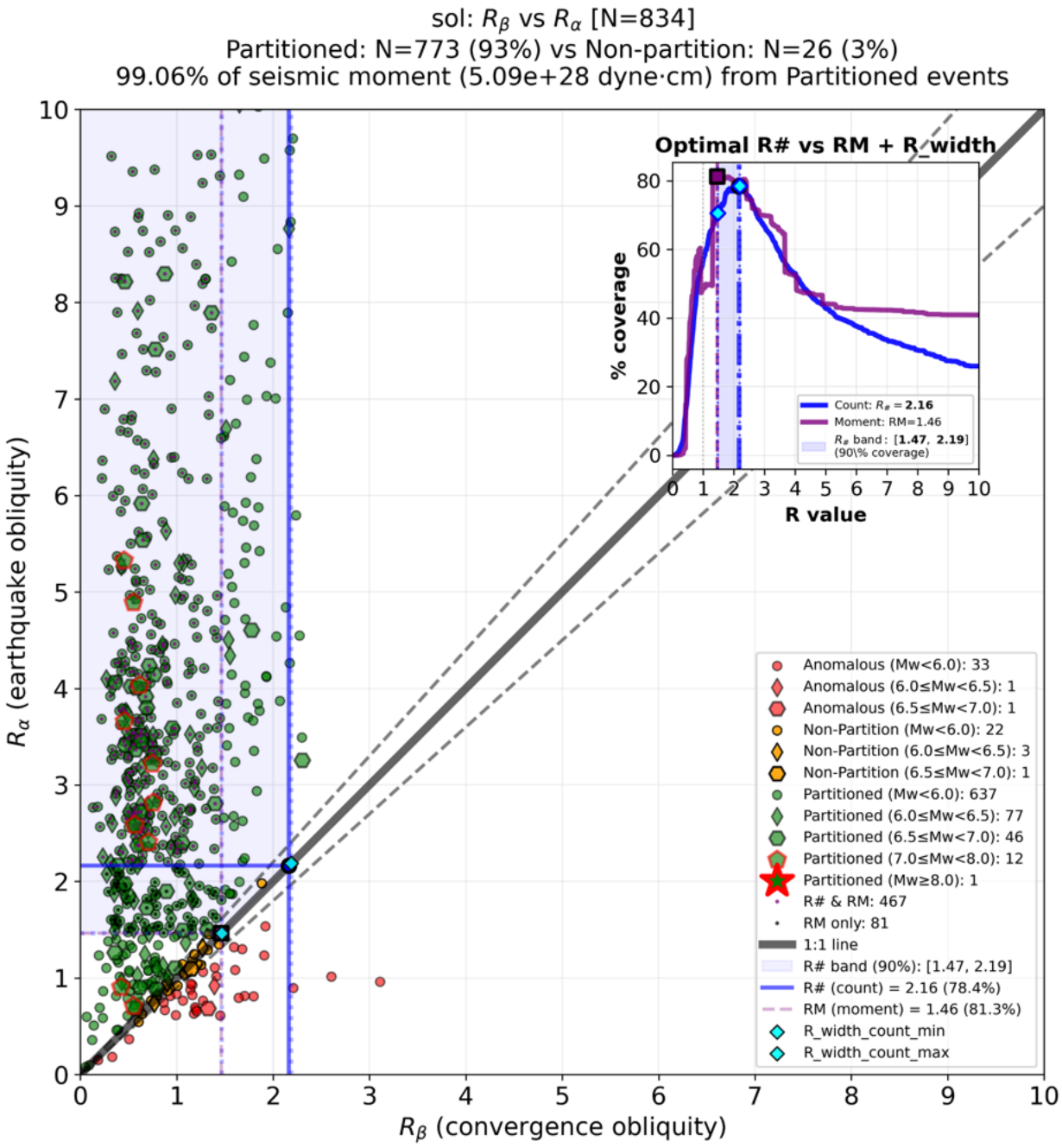


Fig. S-sol-c. Solomons regime classification in Rβ-Rα space.

Normalized regime diagram showing partitioned, non-partitioned, and anomalous events, with R#, R_M, and R#90% interval. See Figure SX.c description.

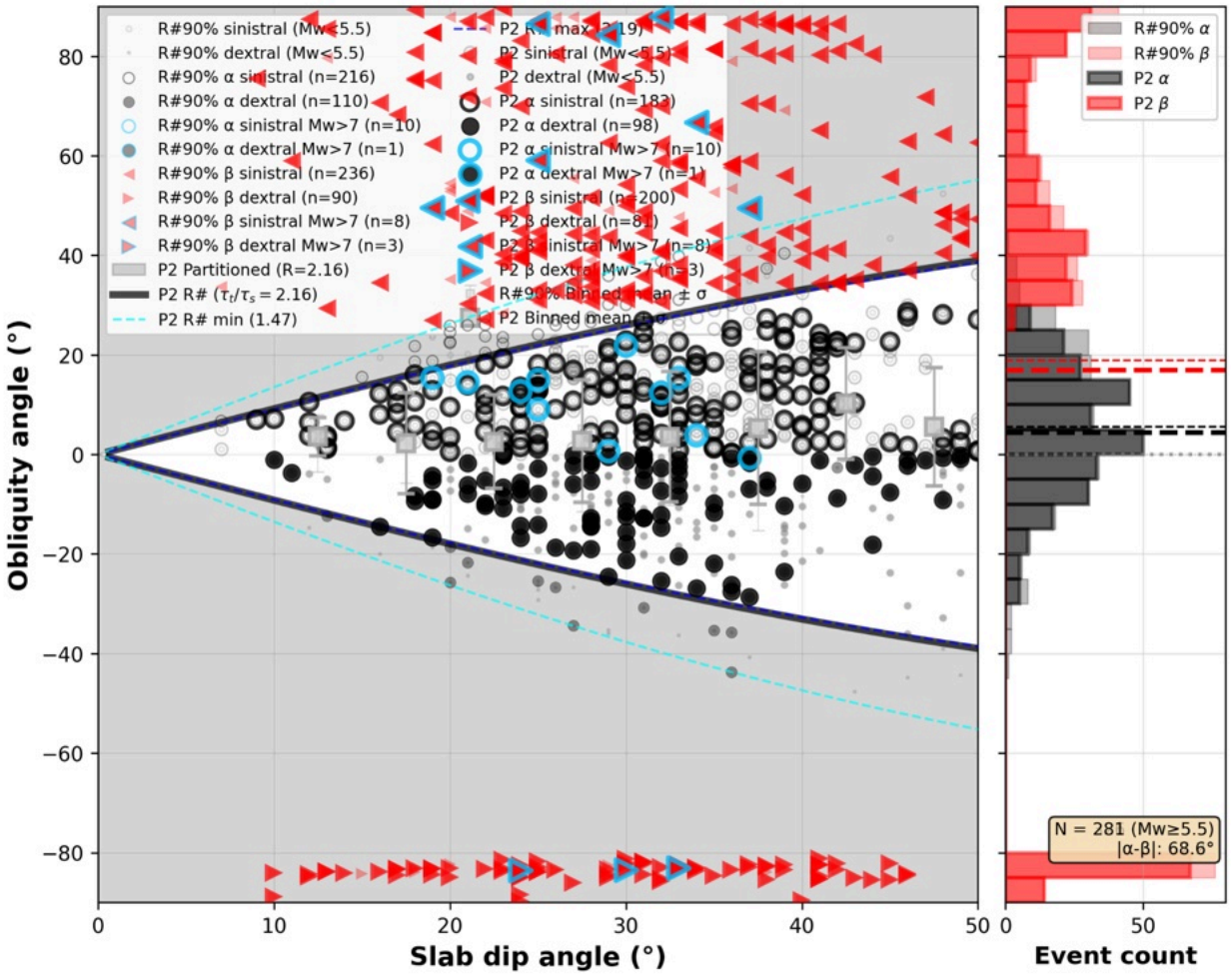


Fig. S-sol-d. Solomons obliquity–dip comparison.

Earthquake slip obliquity and convergence obliquity plotted against slab dip, compared with analytic predictions. See Figure SX.d description.

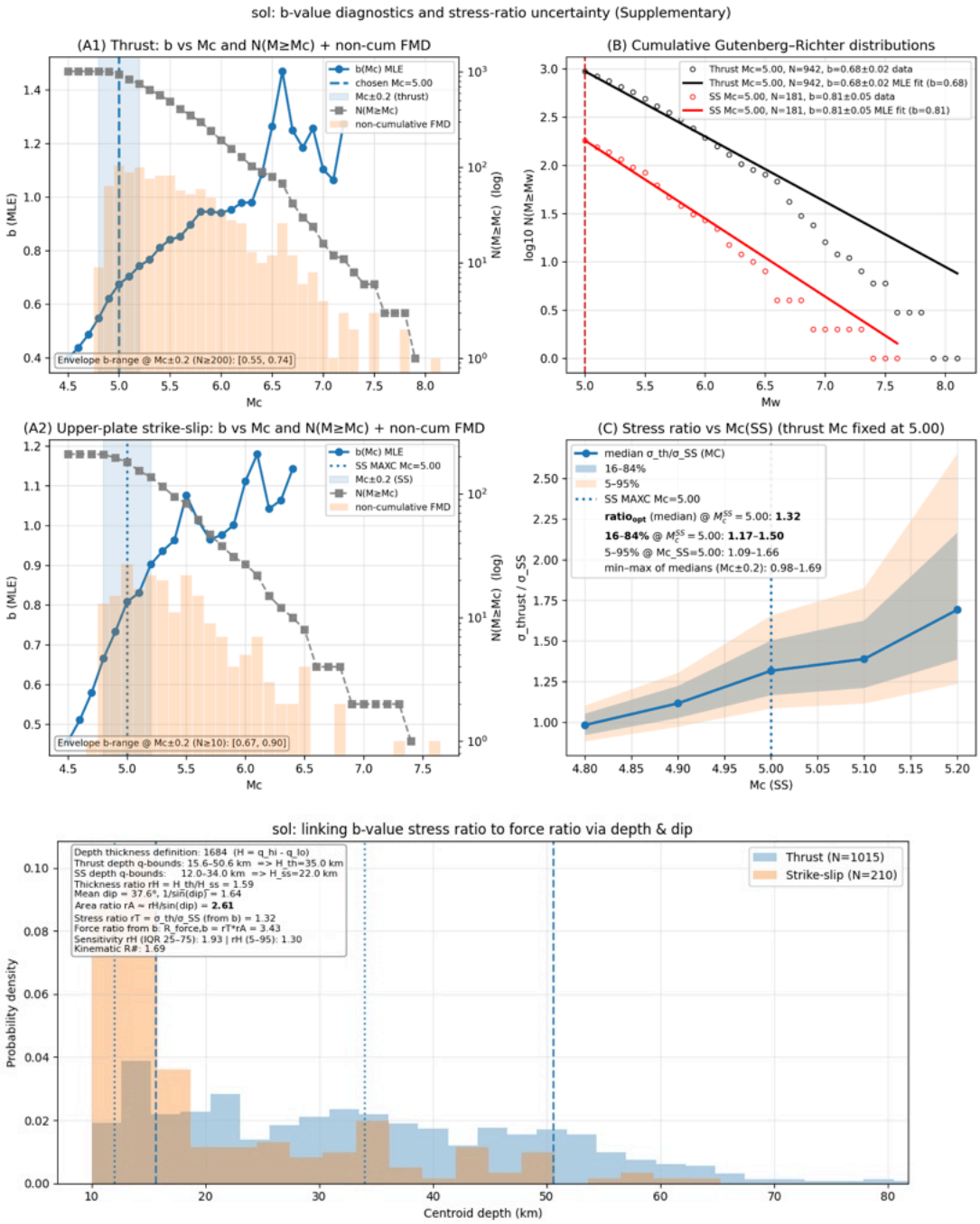
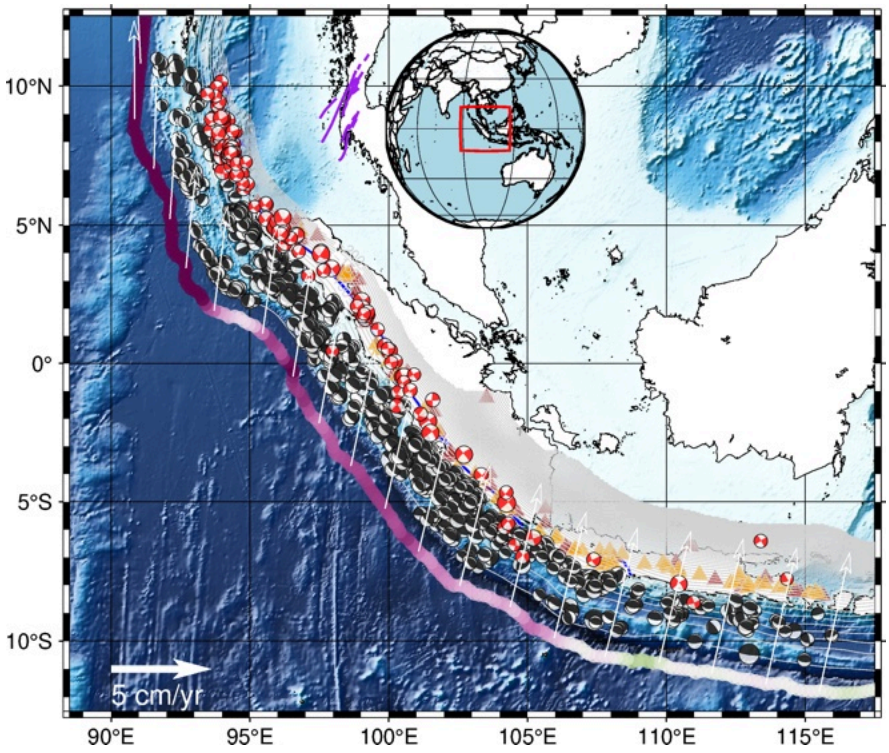


Fig. S-sol-e. Solomons b-value stress-ratio estimate.

b-value and thrust-to–strike-slip stress-ratio estimates for the Solomons subduction zone. See Figure SX.e description.

13-sum: Sumatra



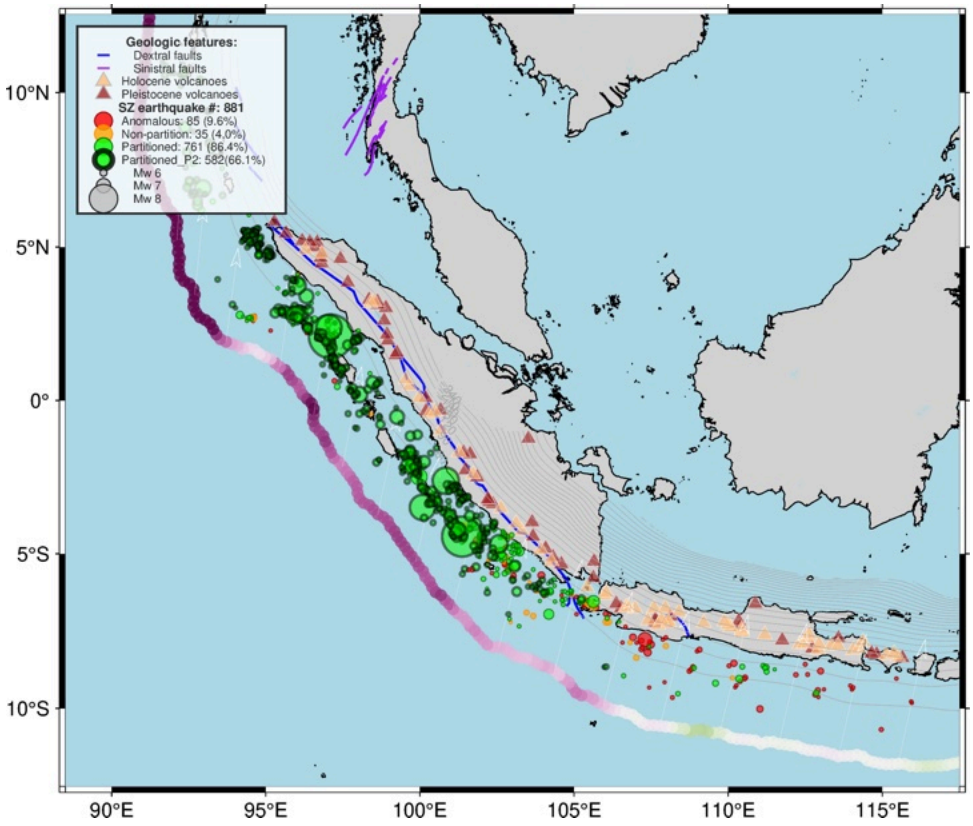


Fig. S-sum-a. Sumatra tectonic setting and earthquake distribution.

Regional map and regime-colored earthquake distribution for the Sumatra subduction zone. See Figure SX.a description for plotted quantities and symbol definitions.

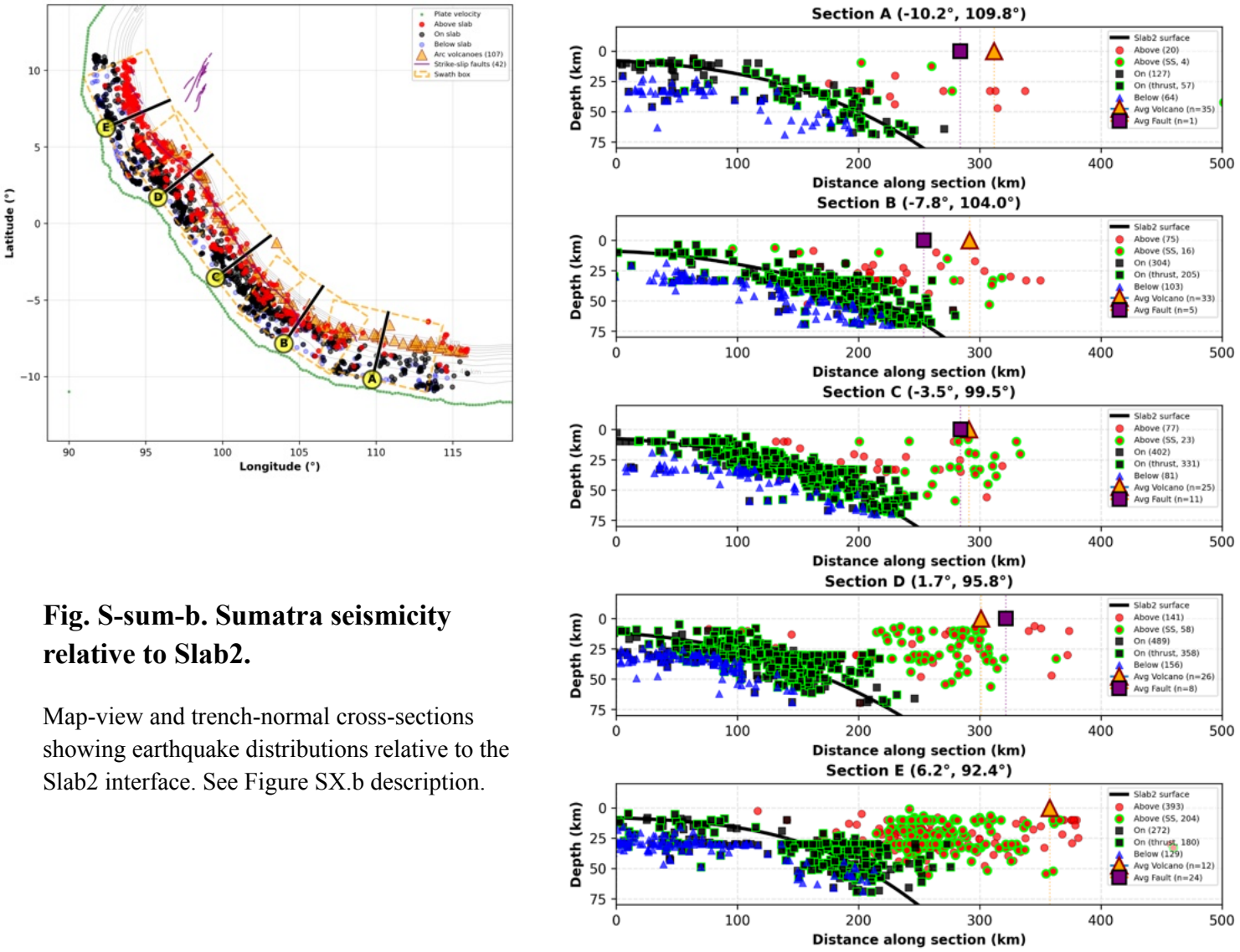


Fig. S-sum-b. Sumatra seismicity relative to Slab2.

Map-view and trench-normal cross-sections showing earthquake distributions relative to the Slab2 interface. See Figure SX.b description.

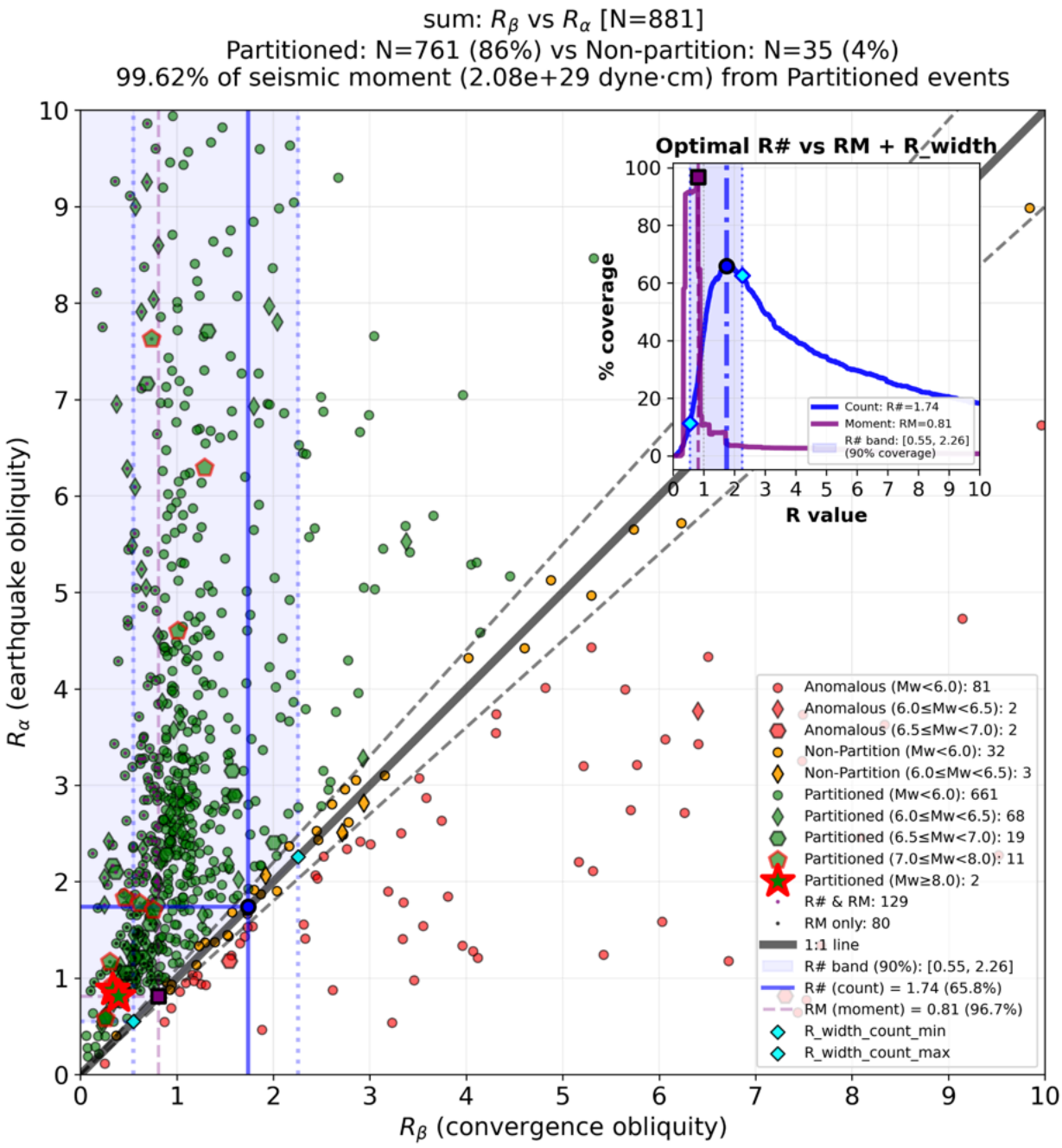


Fig. S-sum-c. Sumatra regime classification in Rβ-Rα space.

Normalized regime diagram showing partitioned, non-partitioned, and anomalous events, with R#, R_M, and R#90% interval. See Figure SX.c description.

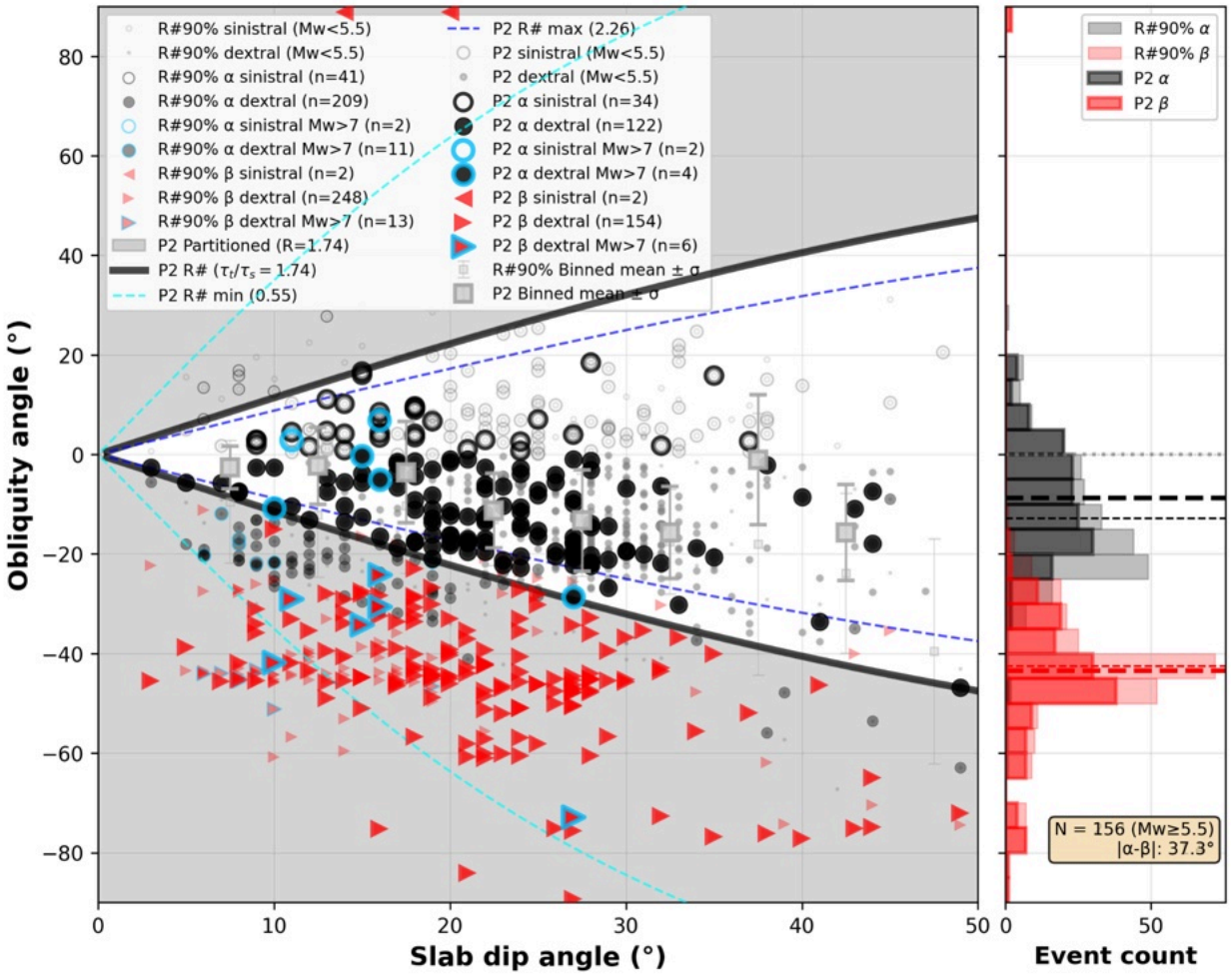


Fig. S-sum-d. Sumatra obliquity–dip comparison.

Earthquake slip obliquity and convergence obliquity plotted against slab dip, compared with analytic predictions. See Figure SX.d description.

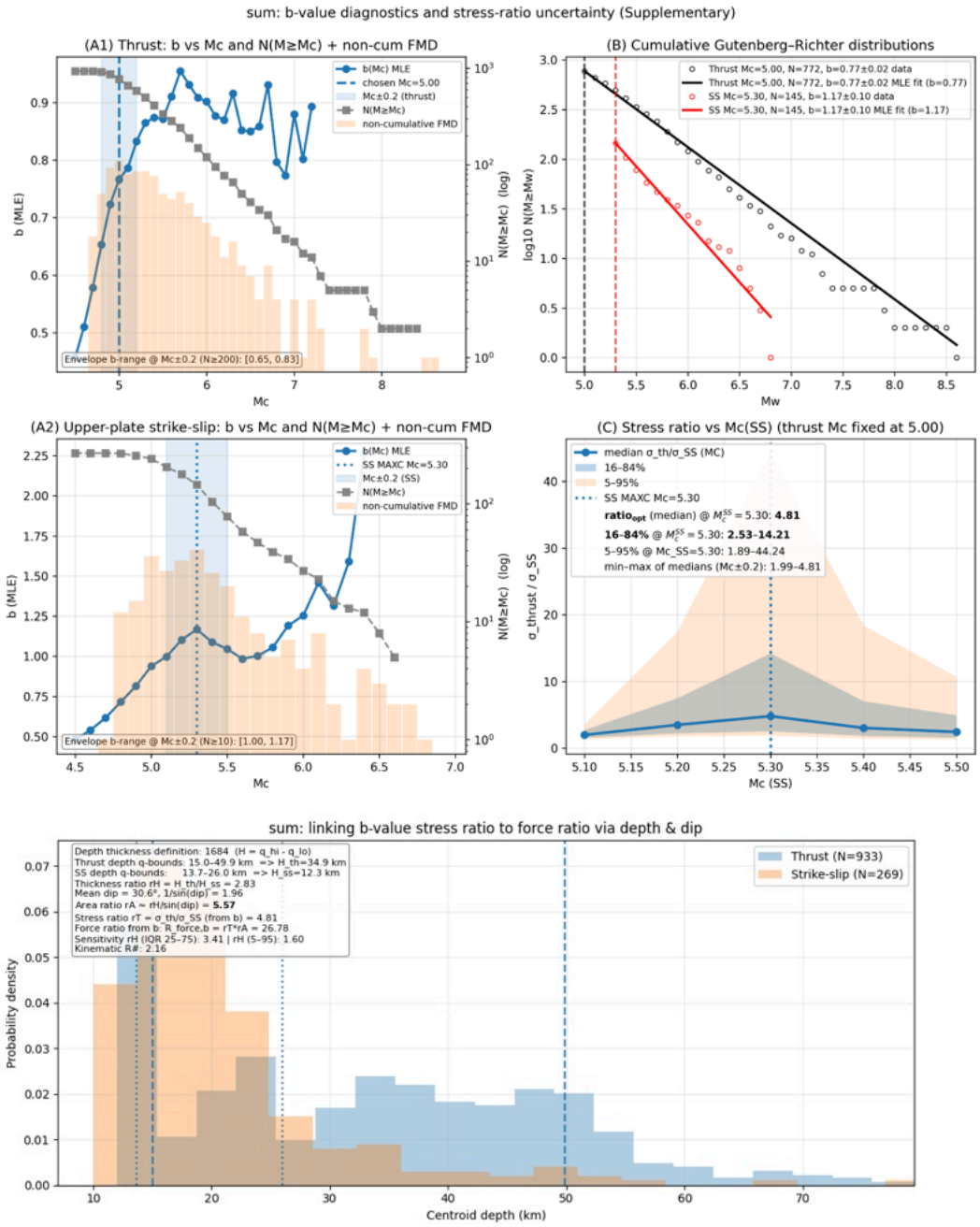


Fig. S-sum-e. Sumatra b-value stress-ratio estimate.

b-value and thrust-to–strike-slip stress-ratio estimates for the Sumatra subduction zone. See Figure SX.e description.

14-van: Vanuatu

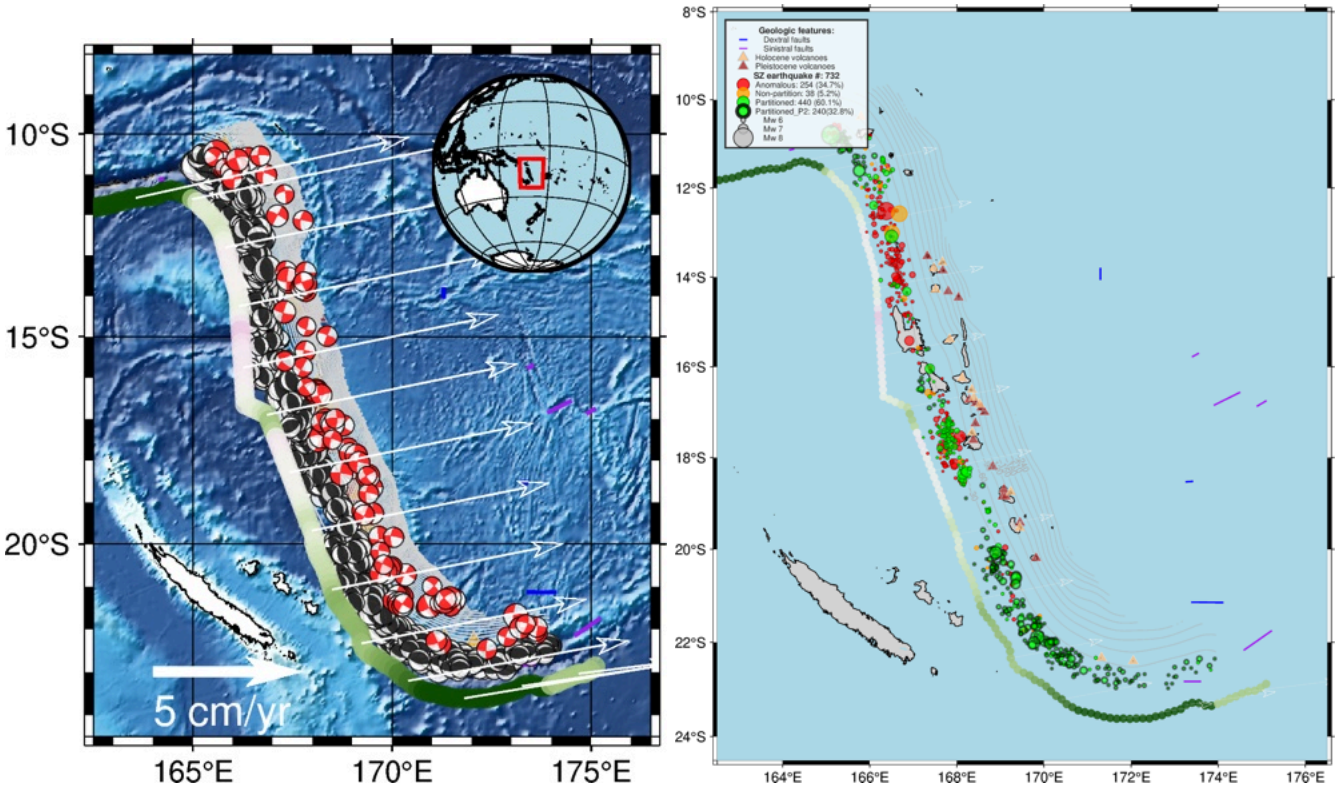


Fig. S-van-a. Vanuatu tectonic setting and earthquake distribution.

Regional map and regime-colored earthquake distribution for the Vanuatu subduction zone. See Figure SX.a description for plotted quantities and symbol definitions.

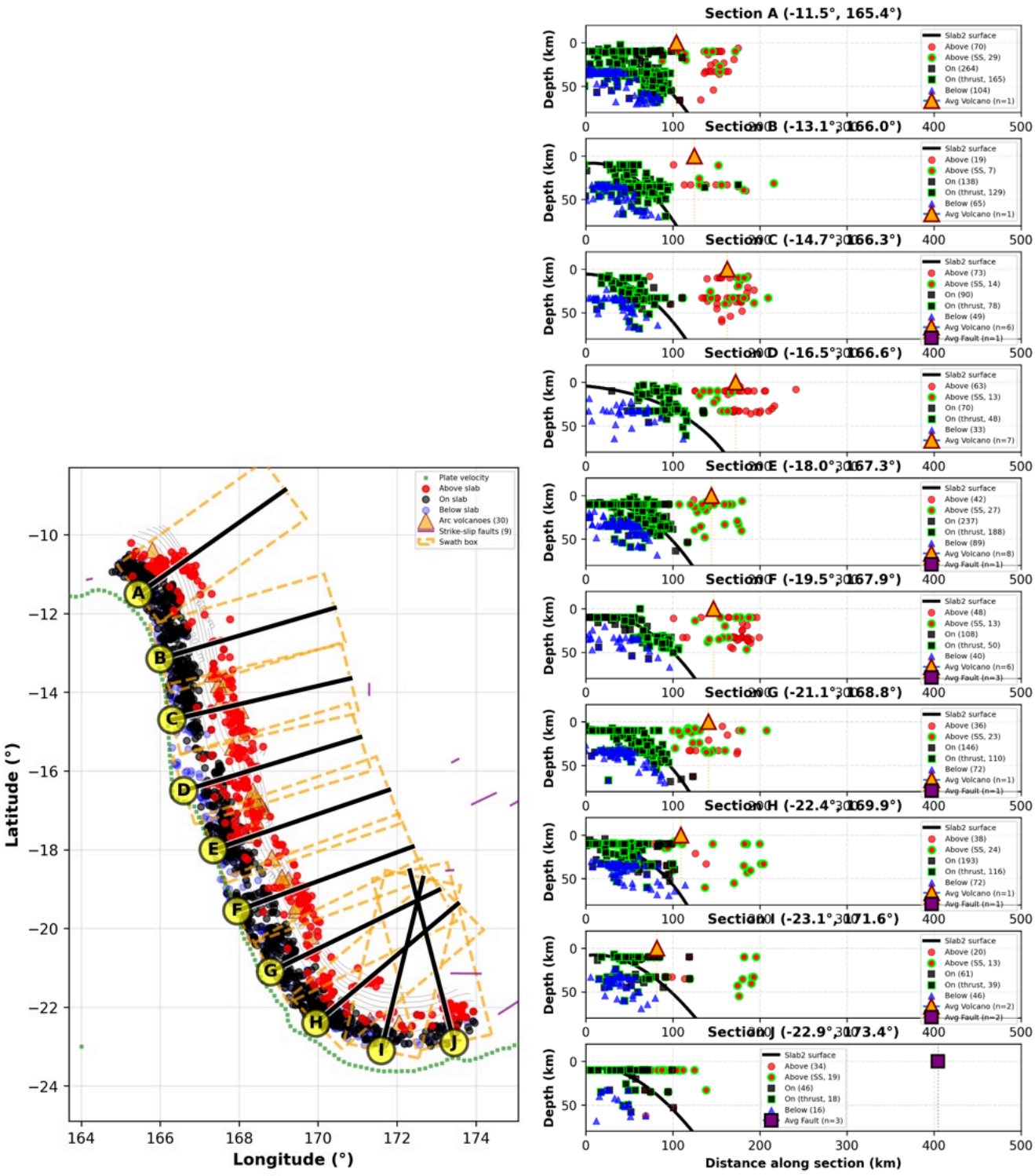


Fig. S-van-b. Vanuatu seismicity relative to Slab2.

Map-view and trench-normal cross-sections showing earthquake distributions relative to the Slab2 interface. See Figure SX.b description.

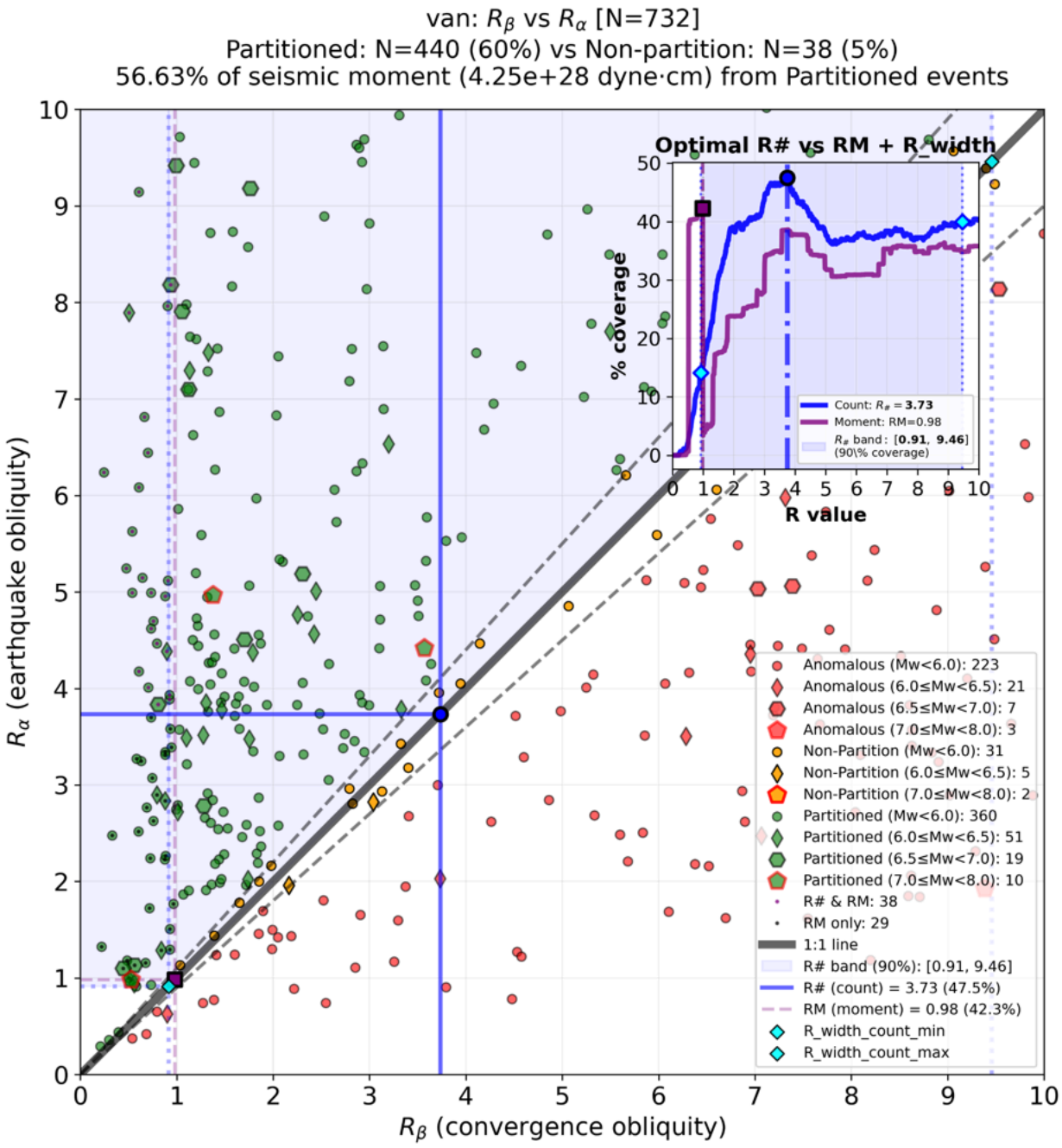


Fig. S-van-c. Vanuatu regime classification in Rβ-Rα space.

Normalized regime diagram showing partitioned, non-partitioned, and anomalous events, with R#, R_M, and R#90% interval. See Figure SX.c description.

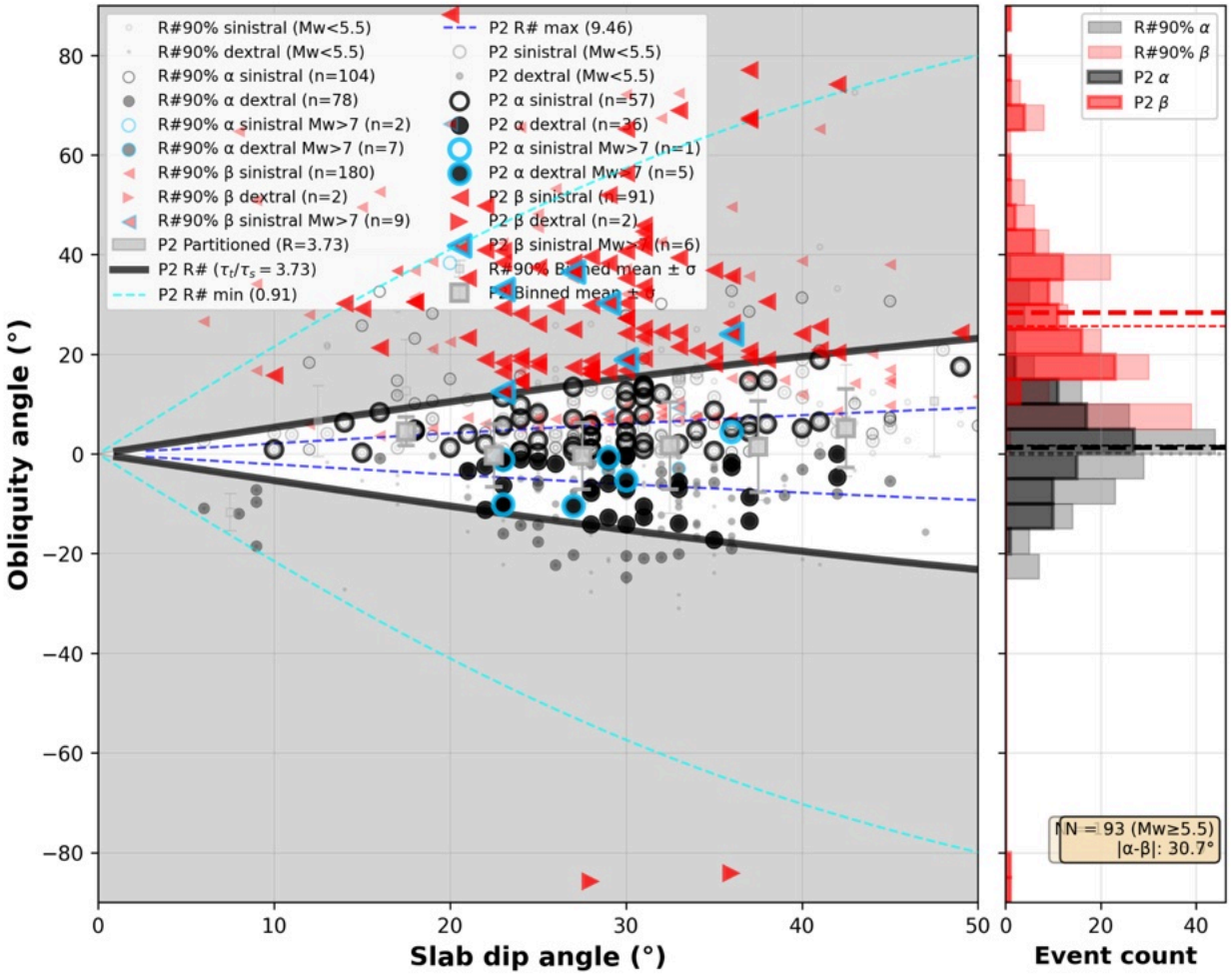


Fig. S-van-d. Vanuatu obliquity–dip comparison.

Earthquake slip obliquity and convergence obliquity plotted against slab dip, compared with analytic predictions. See Figure SX.d description.

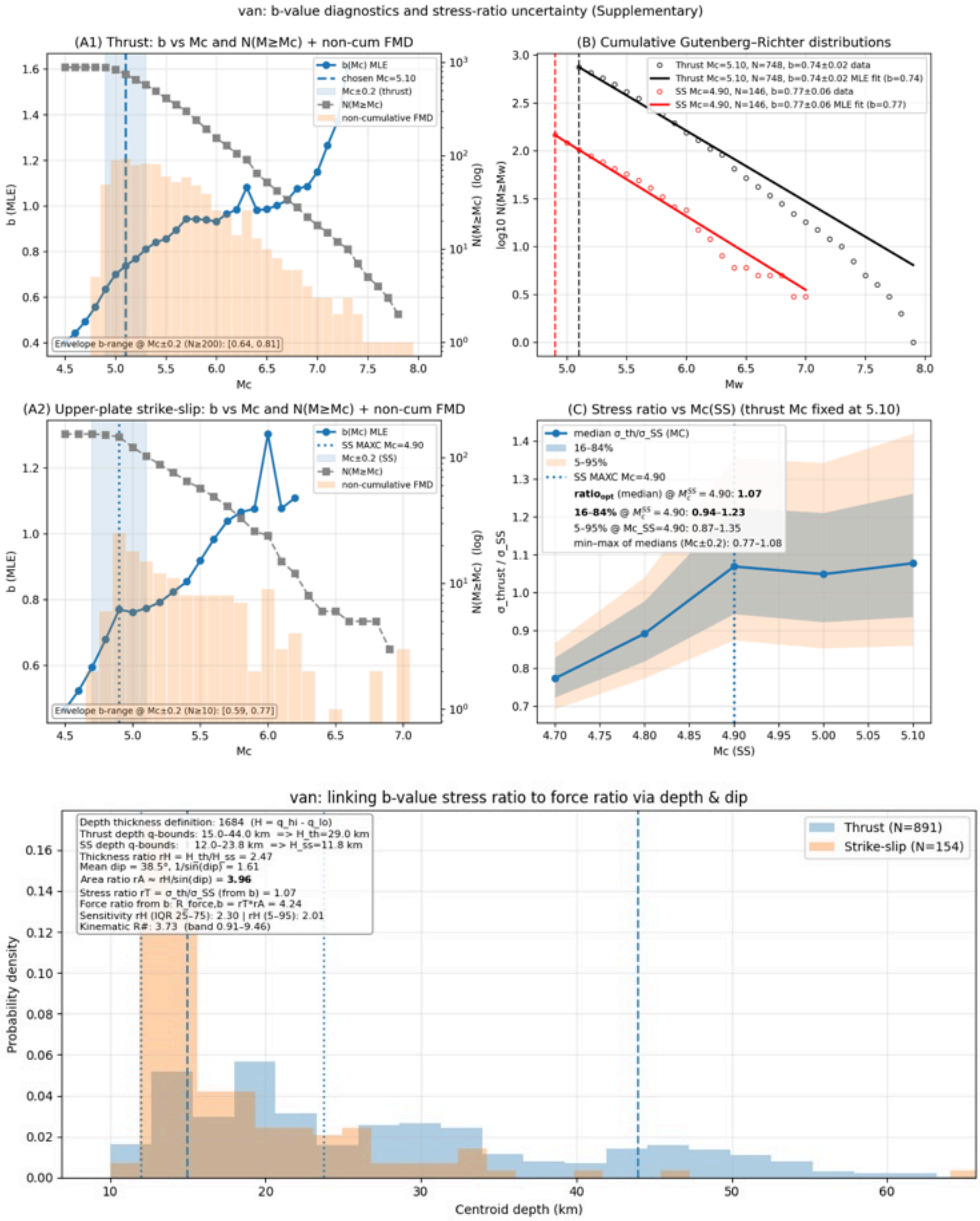


Fig. S-van-e. Vanuatu b-value stress-ratio estimate.

b-value and thrust-to–strike-slip stress-ratio estimates for the Vanuatu subduction zone. See Figure SX.e description.

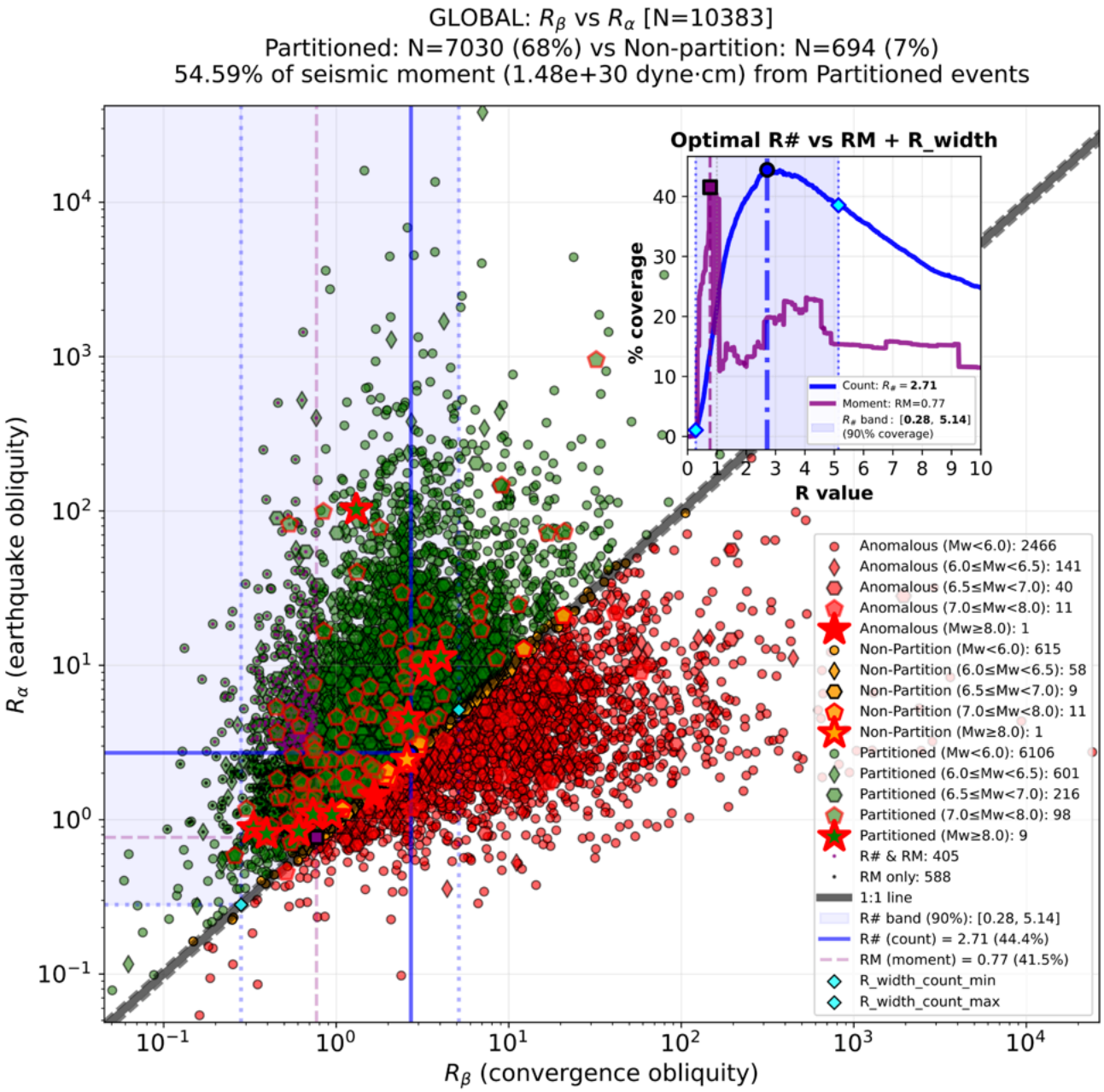


Fig. S-Global. Global data regime classification in Rβ-Rα space.