Supplements of Lesser Antilles Seismotectonic Zoning Model for Seismic Hazard Assessment

Océane Foix[1,2], Stéphane Mazzotti[2], Hervé Jomard[3], Didier Bertil[4], Lesser Antilles Working Group

[1]Univ. Grenoble Alpes, Univ. Savoie Mont Blanc, CNRS, IRD, UGE, ISTerre, Grenoble, France.
[2]Géosciences Montpellier, Université de Montpellier, CNRS, Université des Antilles, France.
[3]Institut de Radioprotection et Sûreté Nucléaire, PSE-ENV, SCAN, BERSSIN, Fontenay-aux-Roses, France.
[4]Bureau de Recherche Géologique et Minière, Orléans, France.

Correspondence to: Océane Foix (oceane.foix@univ-grenoble-alpes.fr / oceane.foix@umontpellier.fr)

S1 Area sources and corresponding characteristics for the upper plate crust, the subduction interface, the subducted slab and the mantle wedge.

Zone ID (identifications): DP: Downgoing plate, AW: Accretionary Wedge, AWD: Accretionary Wedge Death, FA: Forearc, A: Arc, FAA: Forearc and Arc, AP: Anegada Passage, BA: Backarc, MF: Muertos Fault, NB: North Boundary, SB: South Boundary, MGG: Marie-Galante graben.

Significant earthquakes: Main historical or instrumental earthquakes potentially associated with each zone, based on the ISCU-Cat catalog locations or the indicated references: °: USGS, M: Meng et al., (2012), F: Feuillet et al. (2011), R: Reid and Taber, (1920), B: Bernard & Lambert, (1988), RO: Russo & Okal, (1992), T: Tarazona et al. (2023) and ref. therein, D: Davey and Rsitau (2011), mc: McCann et al., (1982), do: Dorel (1981). Additional notes: *: Historical seismicity, with macro-seismic data currently being processed, £: Doubt about the source location, which differs according to the references, $: No information in literature. Details in Foix et al., (2023a).

Mmax: Maximum magnitudes for each zone based on the largest catalog event (Mmax.cat), the longest potential seismogenic fault, following the Wells and Coppersmith (1994) relationship (Mmax.struct), and the largest known earthquake in a similar tectonic setting (Mmax.proxy).

GR quality: indication of the quality and usability of the instrumental catalog to derive Gutenberg-Richter statistics in each zone. Unusable: not enough data; Questionable: enough data but significant problems in the GR distribution (offsets, changes off slope); Usable: enough data and GR distribution of good quality.

Zone ID	Structural Region	Significant earthquakes	Deformation regime	Mmax	GR quality	Area source boundaries
DP-1	Outer-rise	2016, M=5.6[U]	Normal to strike-slip	Mmax.cat 4.5 Mmax.struct - Mmax.proxy 8-8.6[M]	Unusable	**E**: 200 km to trench **W:** trench **N:** change in crust properties **S:** subduction end
DP-2	Outer-rise	2003, M=6.7[U]	Normal to strike-slip	Mmax.cat 6.0 Mmax.struct - Mmax.proxy 8-8.6[M]	Questionable	**E**: 200 km to trench **W:** trench **N:** subduction end **S:** change in crust properties
AW-1	Accretionary prism	1728, 1890, 1922, EI=7* 1910, Mw=6.5[£]	Reverse	Mmax cat 5.7 Mmax structure - Mmax proxy -	Questionable	**E**: trench **W:** backstop **N:** Tiburon ridge **S:** prism disappearance
AW-2	Accretionary prism	1900, EI=8*	Reverse	Mmax cat 4.9 Mmax structure - Mmax proxy -	Questionable	**E**: trench **W:** backstop **N:** Barracuda ridge **S:** Tiburon ridge
AW-3	Accretionary prism	-	Strike-slip	Mmax.cat 4.6 Mmax.struct - Mmax proxy -	Unusable	**NE**: trench **SW:** 10 km from Bunce fault **W:** Puerto-Rico subduction **S:** Barracuda ridge
AW-4	Puerto-Rico subduction end	-	Reverse	Mmax.cat 4.9	Usable	**Model limit**: do not include all the seismicity
AWD	Accretionary prism end	-	Reverse	Mmax.cat 6.1	Usable	**Model limit**: do not include all the seismicity
FAA	Forearc basin and active volcanic arc	1834, 1886, 1905, EI=8* 1865, EI=8.5* 1946, Mw=5.7	Normal	Mmax.cat 5.7 Mmax.struct - Mmax proxy -	Questionable	**E**: backstop **W:** volcanic arc end **N:** geodetic velocity gradient **S:** El-Pilar system
FA-1	Forearc basin	1839, EI=8* 1702, EI=8.5* 2014, Mw=5.2	Normal	Mmax.cat 5.2 Mmax.struct 7.0-7.3 Mmax.proxy -	Questionable	**E**: backstop **W:** volcanic arc beginning **N:** MGG beginning **S:** geodetic velocity gradient
FA-2a	Marie-Galante graben	1851, EI=7* 1897, EI=8* 1950, Mw=5.7[$]	Normal	Mmax.cat 5.7 Mmax.struct 7.0-7.3 Mmax.proxy -	Questionable	**E**: MGG end **W:** MGG end **N:** change in geodetic velocity direction, north of Gosier Fault **S:** south of Morne-Piton Fault
FA-2b	Forearc basin	1914, Mw=7.0[£]	Normal	Mmax.cat 4.9 Mmax.struc - Mmax.proxy -	-	**E**: backstop **W:** MGG beginning **N:** FA-2a north extension

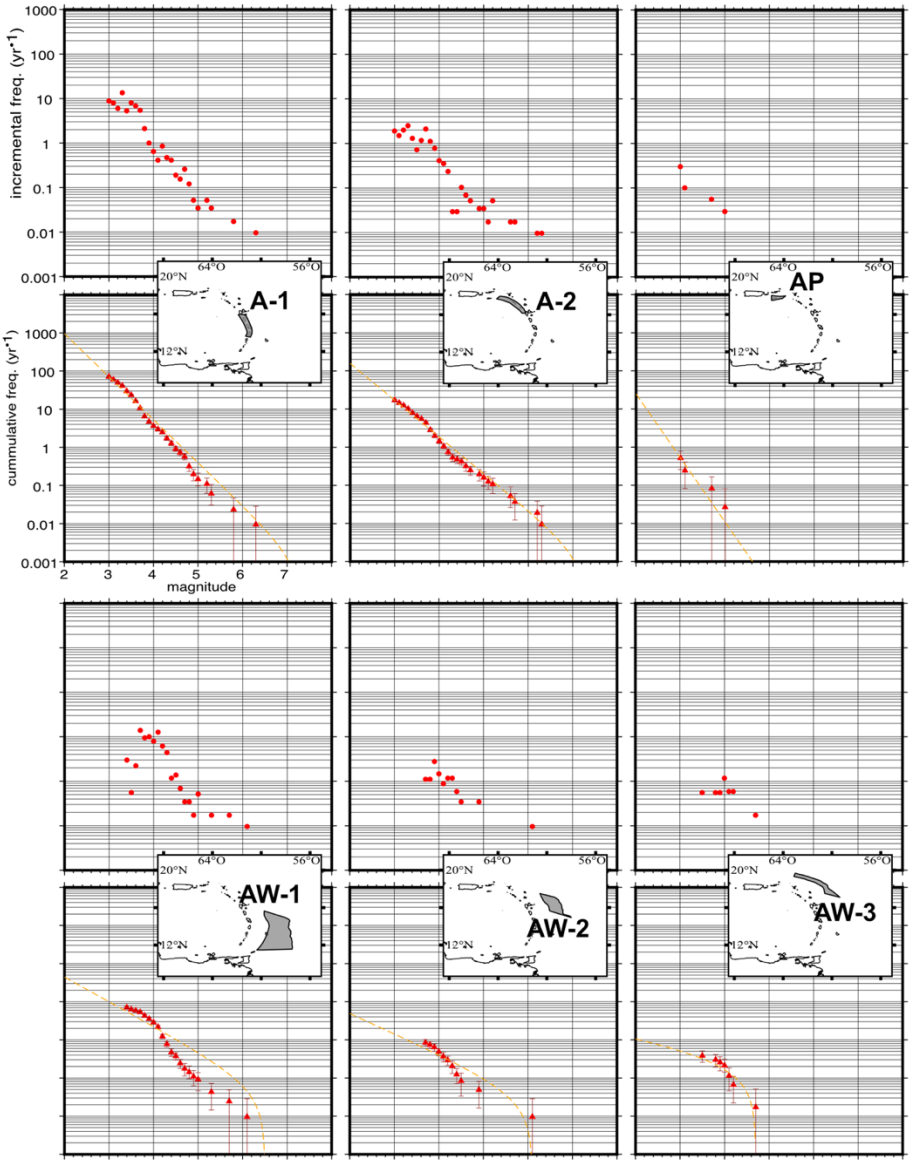
						S: FA-2a south extension
FA-3	V-shaped basin and inactive volcanic arc	1843, EI=9.5* 1690, 1842, 1735, 1895, EI=7.5* 1967, Mw=6.4 1974, EI=8, Mw=6.5-7.5[£]	Normal	Mmax.cat 6.4 Mmax.struct 7.0-7.3 Mmax proxy -	Questionable	**E**: backstop **W:** active volcanic arc **N:** seismicity rate decrease **S:** MGG beginning
FA-4	Anegada faults and basins	1835, EI=7.5* 1925, Mmax=6.2[£]	Normal	Mmax.cat 6.2 Mmax.struct 7.0-7.5 Mmax.proxy -	Questionable	**SE**: seismicity rate increase **W:** Anegada Passage end **N:** Bunce fault **SW:** active volcanic arc
A-1	Active volcanic arc	1870, 1906, EI=7.5* 2004, M=6.3	Normal	Mmax.cat 6.3 Mmax.struct 7.0-7.3 Mmax.proxy -	Usable	**E**: forearc basin **W:** volcanic arc end **N:** MGG beginning **S:** geodetic velocity gradient
A-2	Active volcanic arc	1690, EI=9[F] 1833, 1848, EI=7.5* 1935, Mw=6.2 1985, Mw=6.3	Normal to sinistral strike-slip	Mmax.cat 6.3 Mmax.struct 7.0-7.3 Mmax.proxy -	Questionable	**NE:** Kallinago Trough **W:** Anegada passage **S:** volcanic arc end **E:** seismicity rate decrease
AP	South Anegada Passage	1867, M=7.2[R]	Normal to strike-slip	Mmax.cat 3.9 Mmax.struct 7.0-7.5 Mmax.proxy -	Unusable	**E**: volcanic arc **W:** Anegada Passage end **N:** Puerto-Rico Fault system **S:** Muertos Fault system
BA	Backarc region	-	-	Mmax.cat 5.6	Usable	**Model limit**: do not include all the seismicity
MF	Muertos fault eastern end	-	Reverse	Mmax.cat 4.7	Unusable	**Model limit**: do not include all the seismicity
NB	Puerto-Rico subduction eastern end	-	Reverse	Mmax.cat 5.9	Usable	**Model limit**: do not include all the seismicity
SB	El Pilar fault system eastern end	-	Strike-slip	Mmax.cat 6.9	Usable	**Model limit**: do not include all the seismicity
UI-1	Large slip earthquake domain	1839, M=7.5-8[B] 1919, Mw=6.06[$] 2015, Mw=6.5[$]	Reverse	Mmax.cat 6.5 Mmax.struct >9 Mmax.proxy 8.5-9	Questionable	**E**: trench **W:** 35 km depth **N:** Tiburon Ridge **S:** slab end
UI-2	Large slip earthquake domain	1843, M=8-8.5[B] 1906, M=6.3[£] 2016, Mw=6[$]	Reverse	Mmax.cat 6.3 Mmax.struct >9 Mmax.proxy 8.5-9	Questionable	**E:** trench **W:** 35 km depth **NW**: Puerto-Rico subduction **S:** Tiburon Ridge
UI-3	Puerto-Rico subduction	-	Reverse	Mmax.cat 6.1	Usable	**Model limit**: do not include all the seismicity
DI-1	Moderate	1946, Ms 6-7[RO]	Reverse	Mmax.cat 5.8	Usable	**E**: 35 km depth

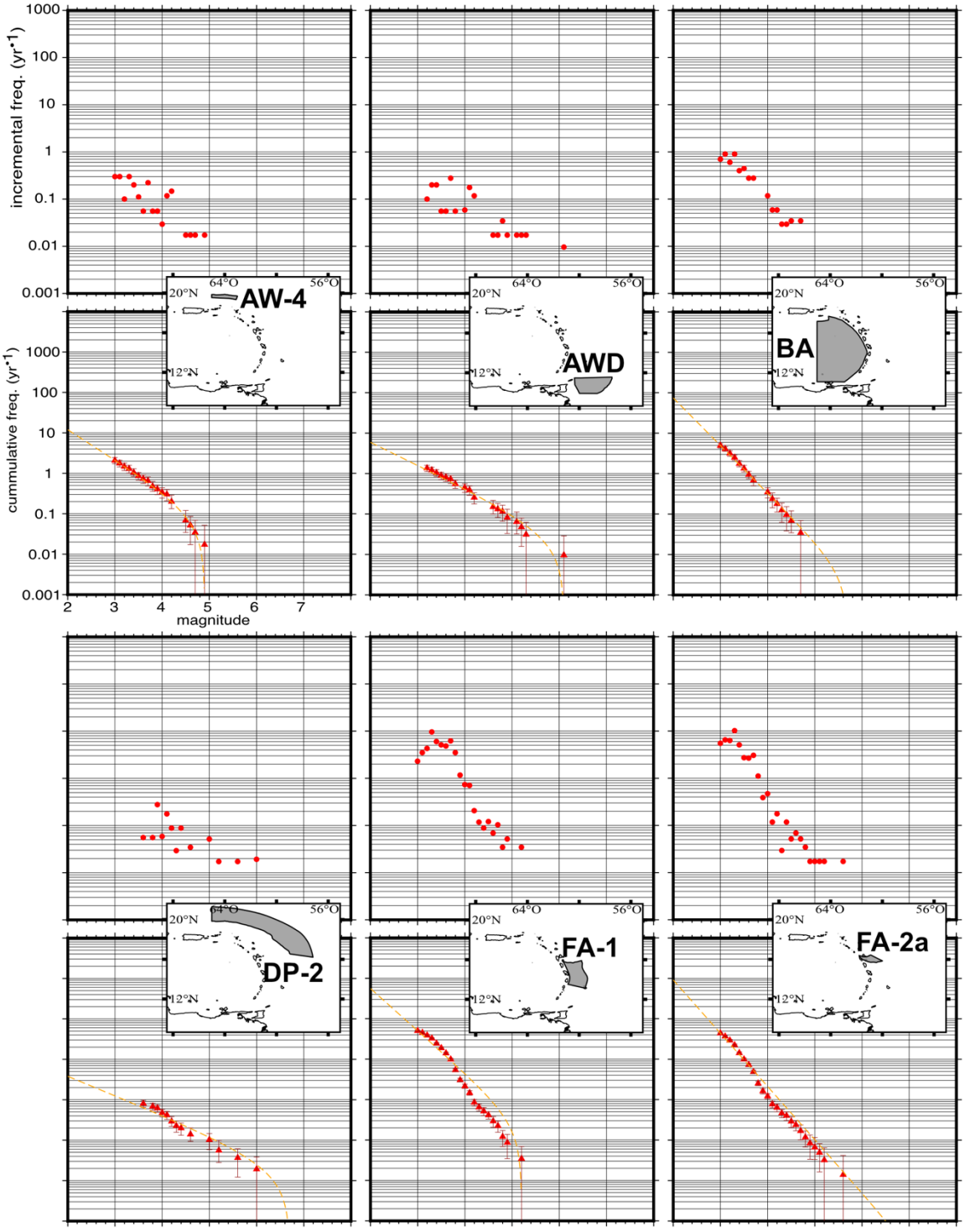
	slip domain	1999, Mw=5.8 2017, Mw=5.8		Mmax.struct >9 Mmax.proxy 7-8		**W:** 65 km depth **N:** Tiburon Ridge **S:** slab end
DI-2	Moderate slip domain	1969, Mw=6[$] 1982, Mw=6[$]	Reverse	Mmax.cat 6 Mmax.struct >9 Mmax.proxy 7-8	Usable	**Top**: 35 km depth **W:** 65 km depth **NW**: Puerto-Rico subduction **S:** Tiburon Ridge
DI-3	Puerto-Rico subduction	-	Reverse	Mmax.cat 4.6	Unusable	**Model limit**: do not include all the seismicity
SS-1	Slab near surface - constant low dipping	1986, Mw=5.2[$]	-	Mmax.cat 5.2 Mmax.struct - Mmax.proxy 8-8.3[T]	Usable	**E:** trench **W:** change in slab dip and deformation style **N:** change seismicity rate **S:** end of known slab
SS-2	Slab near surface - constant low dipping	1997, Mw=6.1 1969, Mw=7.2[do] 2014, Mw6.5[£]	Normal to strike-slip	Mmax.cat 6.5 Mmax.struct - Mmax.proxy 8-8.3[T]	Usable	**E**: trench **W:** change in slab dip and deformation style **N:** diffuse limit, change in deformation style **S:** change seismicity rate
SS-3	Slab near surface - constant low dipping	1986, Mw=5.5[$]	-	Mmax.cat 5.5 Mmax.struct - Mmax.proxy 8-8.3[T]	Usable	**SE**: diffuse limit, change in deformation style **W:** Puerto-Rico subduction **N:** trench **S:** change in slab dip
SS-4	Slab near surface - constant low dipping	-	Reverse to strike-slip	Mmax.cat 5.9	Usable	**Model limit**: do not include all the seismicity
SB-1	Slab bending	-	Normal to strike-slip	Mmax.cat 6	Usable	**Model limit**: do not include all the seismicity
SB-2	Slab bending	1984, Mw=5.7[$]	-	Mmax.cat 5.7 Mmax.struct - Mmax.proxy 8-8.3[T]	Questionable	**E**: change in slab dip **W:** change in slab dip **N:** change seismicity rate **S:** change seismicity rate
SB-3	Slab bending	1969, Mw=5.9[$] 1914, Mw=7[£]	Normal-strike-slip to reverse-strike-slip (from north to south)	Mmax.cat 5.9 Mmax.struct - Mmax.proxy 8-8.3[T]	Usable or Questionable	**SE**: diffuse limit, change in deformation style **W:** Puerto-Rico subduction **N:** subduction trench **S:** change in slab dip
SB-4	Slab bending	1988, Mw=5.4[$]	-	Mmax.cat 5.4 Mmax.struct - Mmax.proxy 8-8.3[T]	Usable or Questionable	**SE**: diffuse limit, change in deformation style **W:** Puerto-Rico subduction **N:** change in slab dip **S:** change in slab dip
SB-5	Slab	-	Reverse to	Mmax.cat 5.2	Questionable	**Model limit**: do not include

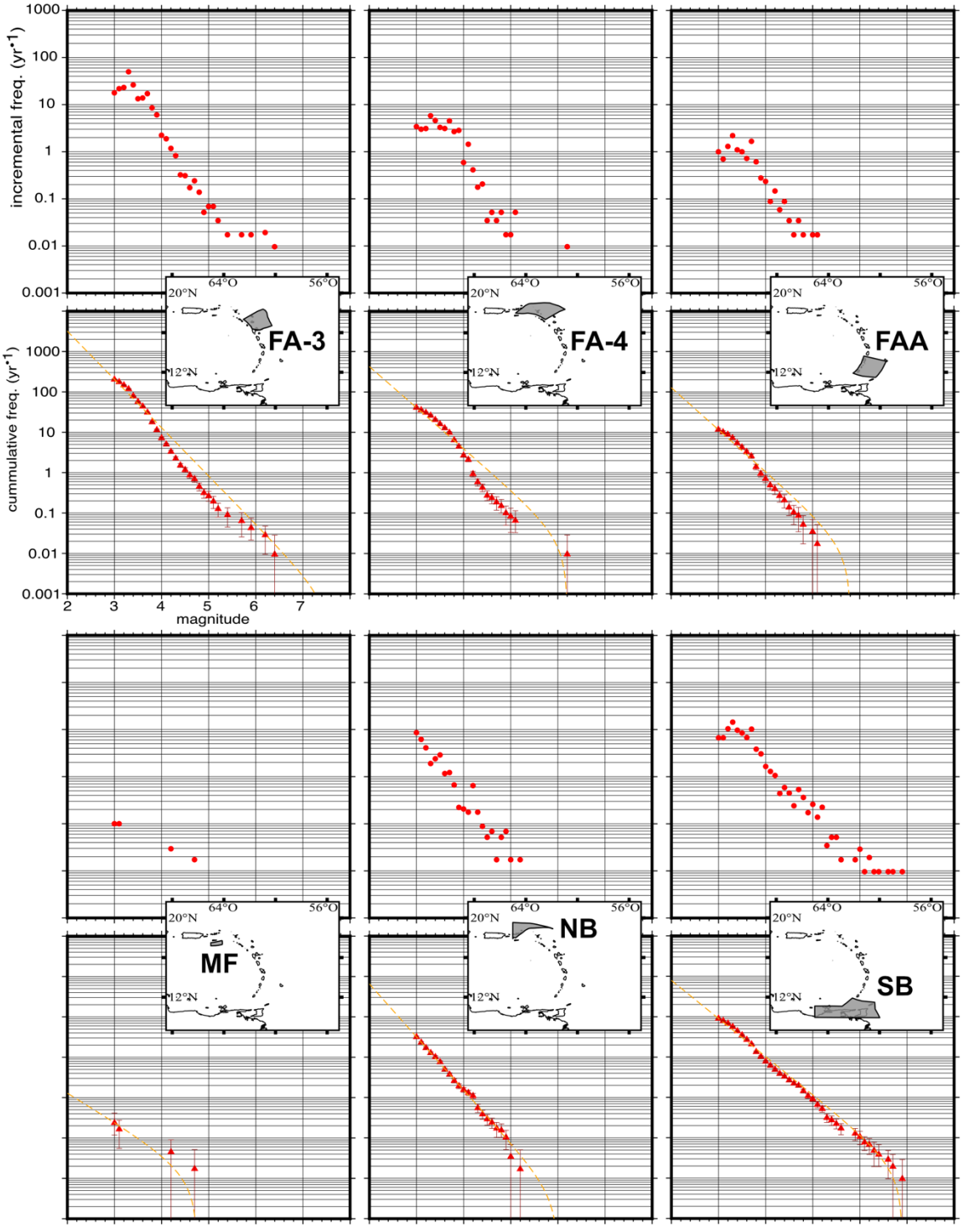
	bending		strike-slip			all the seismicity
SI-1	Slab intermediate depth - constant high dipping	-	-	Mmax.cat 6.5	Questionable	**Model limit**: do not include all the seismicity
SI-2	Slab intermediate depth - constant high dipping	1953, Mw=7.3[RO] 1976, Mw=5.2[$]	Reverse to strike-slip	Mmax.cat 5.2 Mmax.struct - Mmax.proxy 8-8.3[T]	Usable	**E**: change in slab dip **W:** slab detachment **N:** change seismicity rate **S:** change seismicity rate
SI-3	Slab intermediate depth - constant high dipping	1914, Mw=7[£] 2007, Mw=7.4	Normal to strike-slip	Mmax.cat 7.4 Mmax.struct - Mmax.proxy 8-8.3[T]	Usable	**E**: change in slab dip **W:** slab detachment **NE:** diffuse limit, change in deformation style **S:** change seismicity rate
SI-4	Slab intermediate depth - constant high dipping	1987, Mw=5[$]	-	Mmax.cat 5 Mmax.struct - Mmax.proxy 8-8.3[T]	Usable	**SE**: diffuse limit, change in deformation style **W:** Puerto-Rico subduction **N:** change in slab dip **S:** slab detachment
SI-5	Slab intermediate depth - constant high dipping	-	-	Mmax.cat 6.1	Usable	**Model limit**: do not include all the seismicity
SD	Slab detachment area	-	-	Mmax.cat 4.9 Mmax.struct - Mmax.proxy -	Unusable	**E**: slab **W:** end of known slab **S:** end of known slab
PRM	Puerto Rico Mantle Wedge	-	-	Mmax.cat 5.2	Unusable	**Model limit**: do not include all the seismicity
NMS	North Mantle Wedge	-	-	Mmax.cat 4.7 Mmax.struct - Mmax.proxy 4.5[D]	Usable	**N**: Puerto Rico subduction **S**: Increase seismicity rate **E**: Subducting slab and upper crustal Moho **W**: End of seismicity activity
MS	Central Mantle Wedge	1974, Ms=7.1-7.6[mc]	Normal to strike-slip	Mmax.cat 6.3 Mmax.struct – Mmax.proxy 4.5[D]	Questionable	**N**: Decrease seismicity rate **S**: Decrease seismicity rate **E**: Subducting slab and upper crustal Moho **W**: End of seismicity activity
SMS	South Mantle Wedge	-	-	Mmax.cat 5.9	Questionable	**Model limit**: do not include all the seismicity

S2 Magnitude-frequency and Gutenberg-Richter distributions

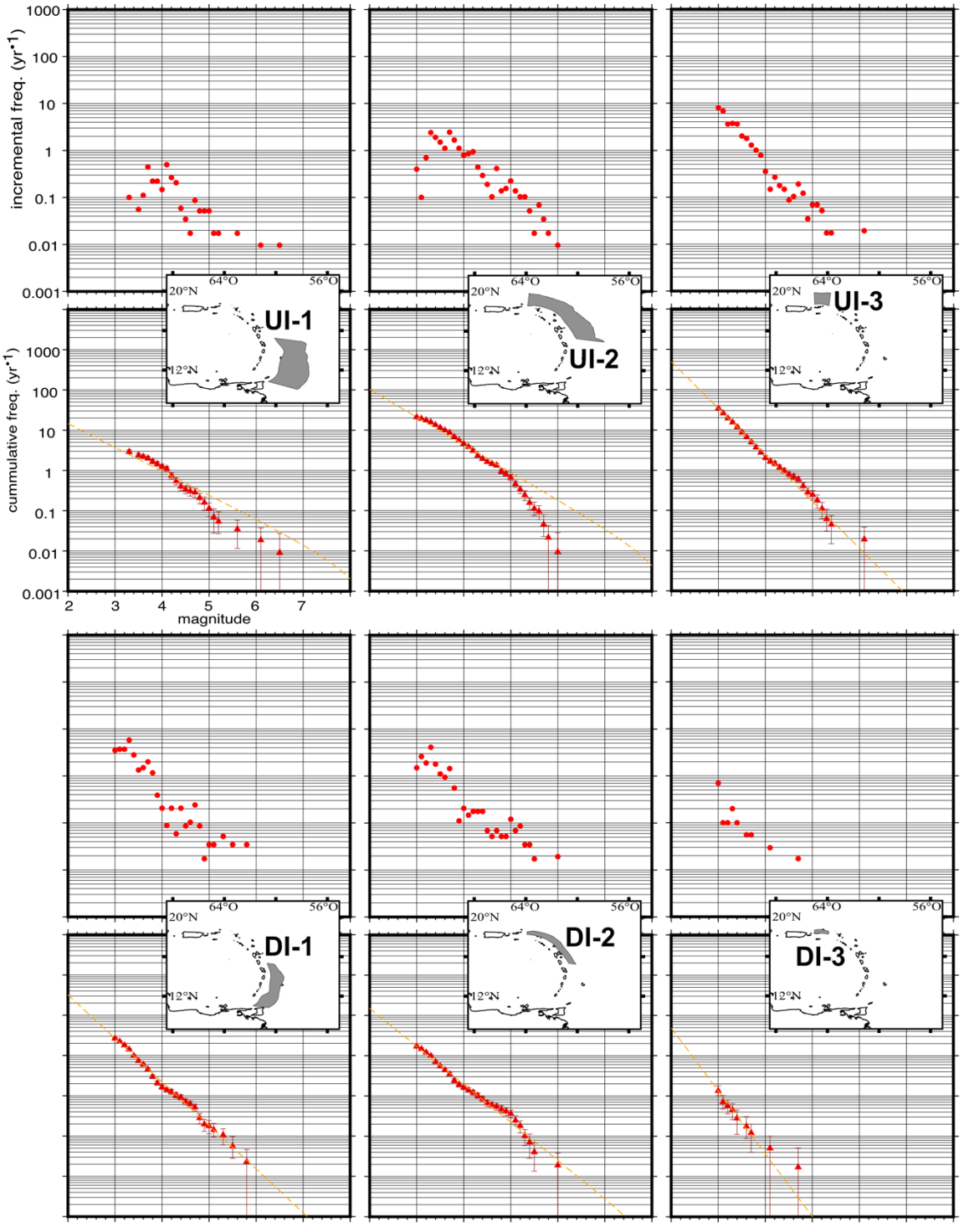
Magnitude-frequency (red dots) and Gutenberg-Richter (orange curve) distributions calculated for each seismogenic area source (inset) when sufficient data were available from the ISC-U catalog (**sect. 3.1**). Area source abbreviations are detailed in **S1**. Completeness does not always reach Mw=3 and changes in GR slope are frequently observed between Mw=3 and Mw=4 (associated with quality rank "Questionable" in **S1**).

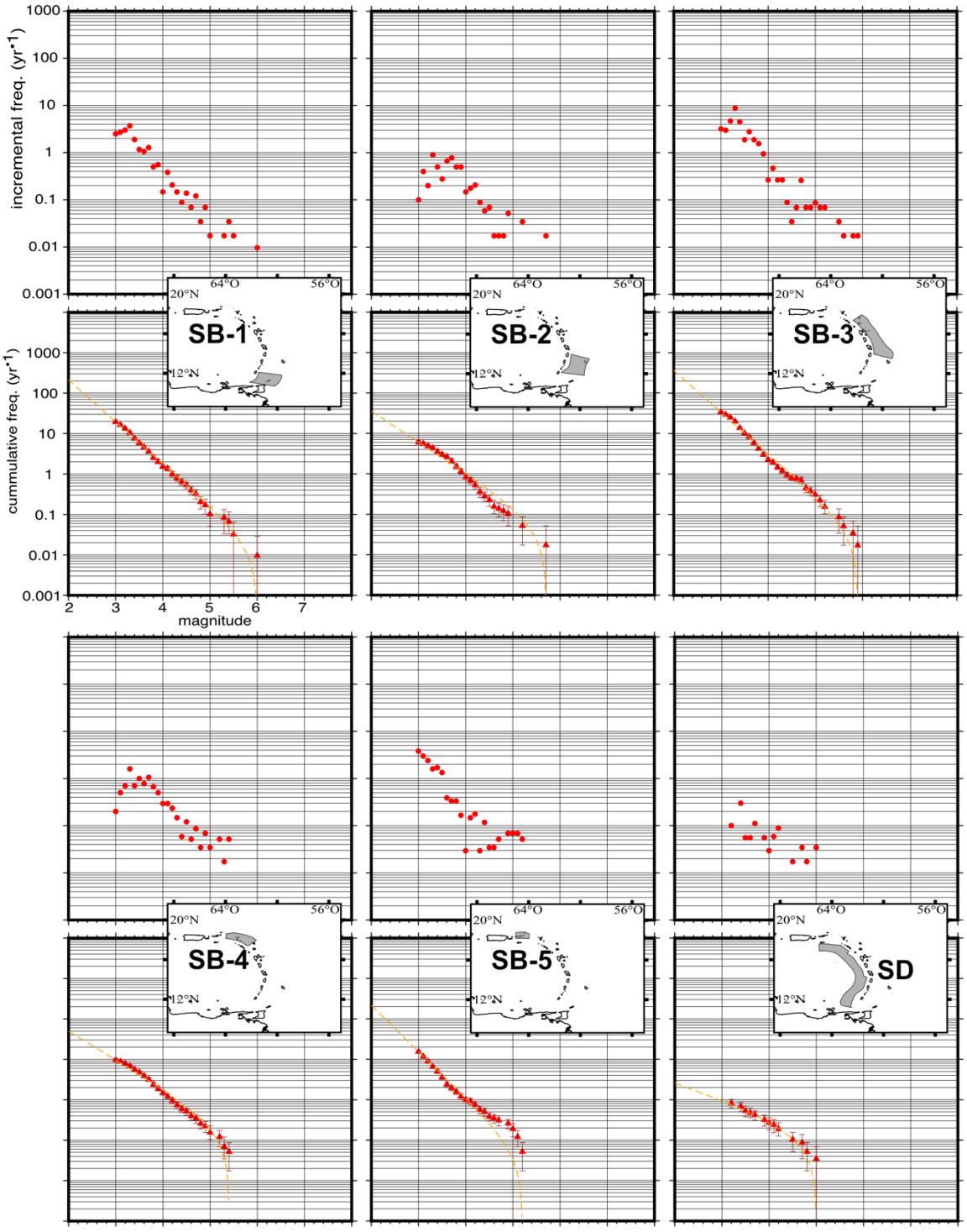


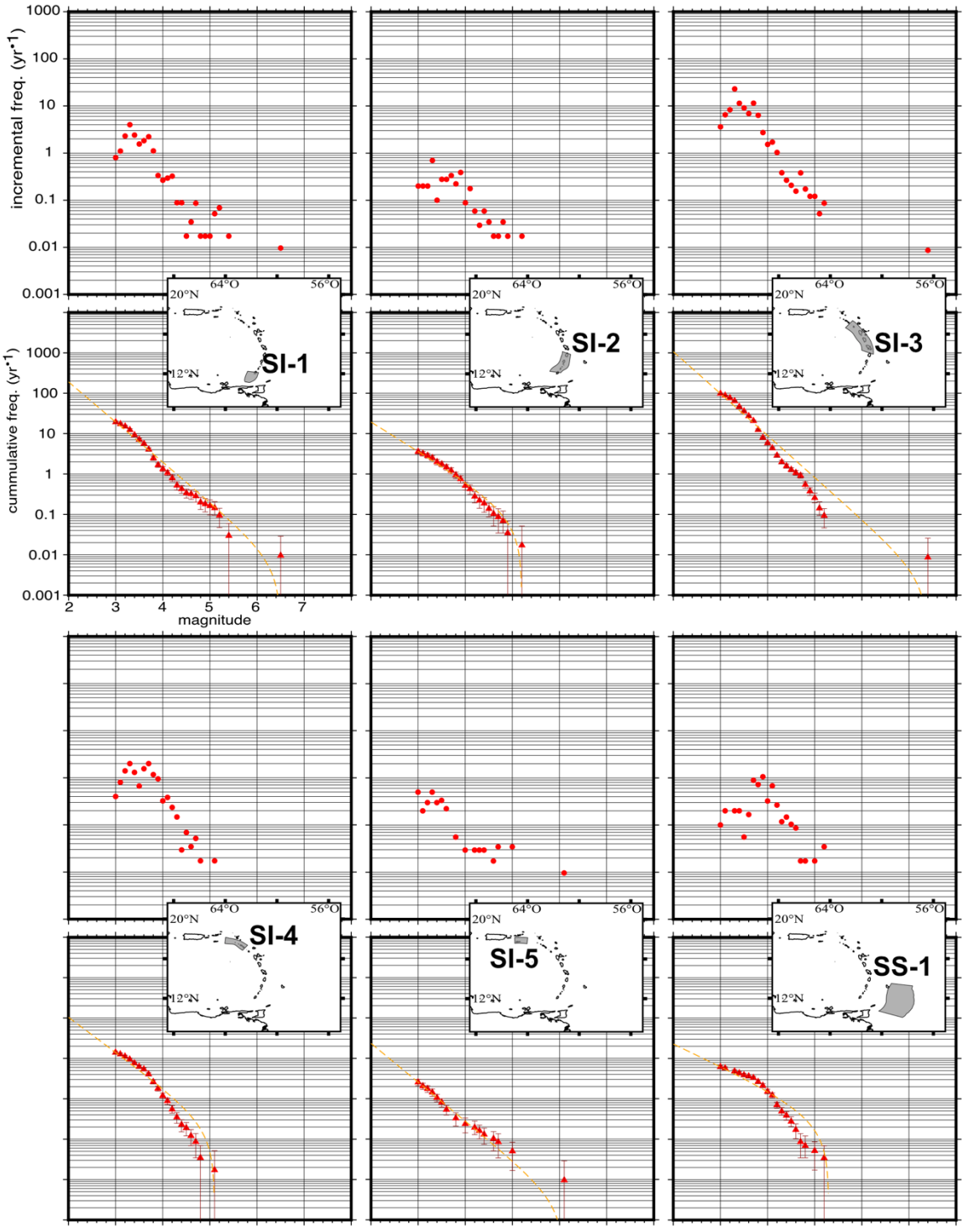

incremental freq. (yr-1)
cummulative freq. (yr-1)
magnitude
AW-4
AWD
BA
DP-2
FA-1
FA-2a
20°N
12°N
64°O
56°O

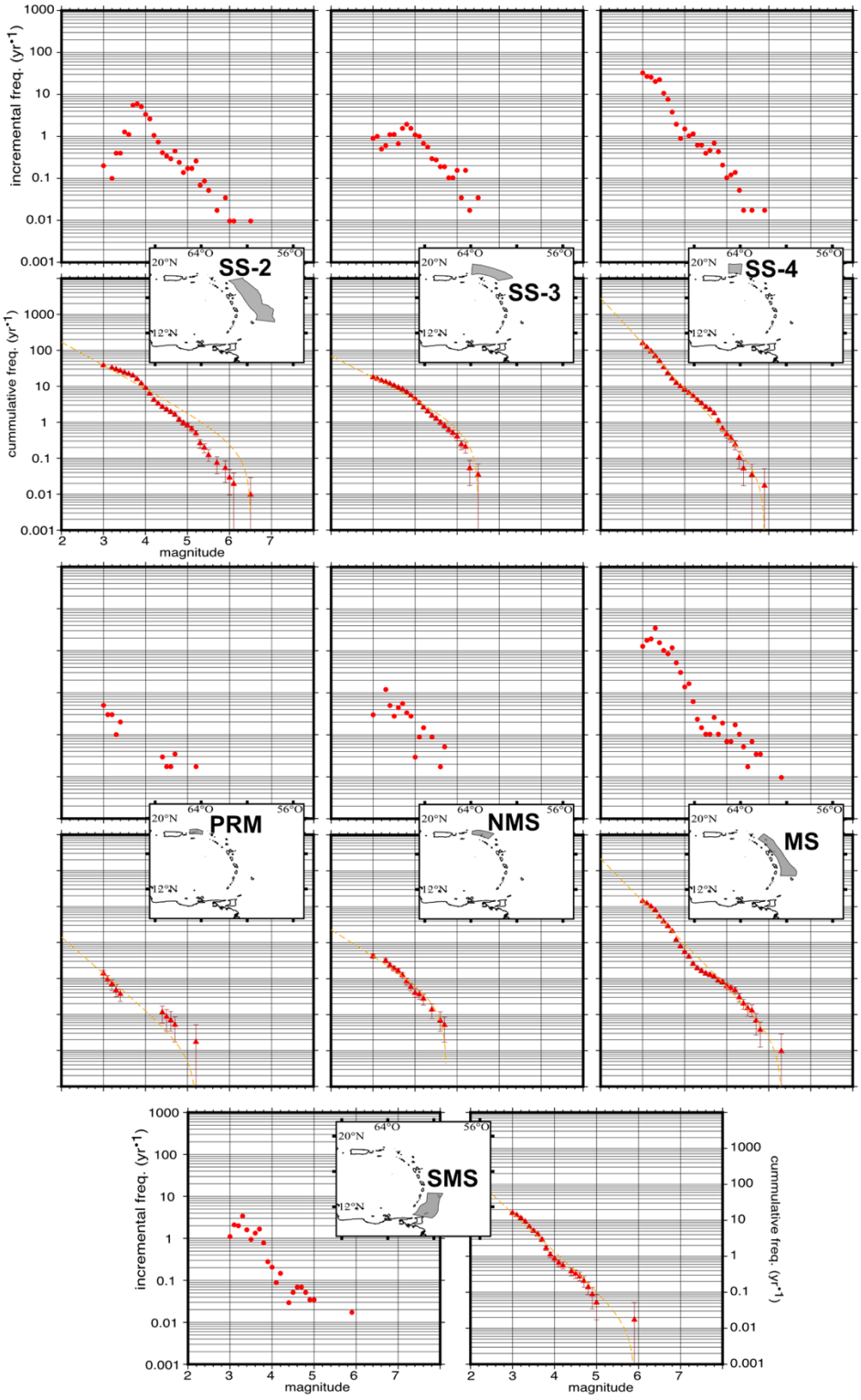

incremental freq. (yr-1)
cummulative freq. (yr-1)
magnitude
FA-3
FA-4
FAA
MF
NB
SB
20°N
12°N
64°O
56°O

40


incremental freq. (yr-1)
cummulative freq. (yr-1)
magnitude
UI-1
UI-2
UI-3
DI-1
DI-2
DI-3
20°N
12°N
64°O
56°O

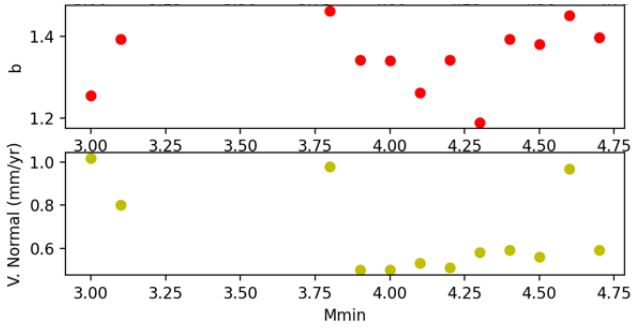

incremental freq. (yr-1)
cummulative freq. (yr-1)
magnitude
SB-1
SB-2
SB-3
SB-4
SB-5
SD
20°N
12°N
64°O
56°O


incremental freq. (yr-1)
cummulative freq. (yr-1)
magnitude
SI-1
SI-2
SI-3
SI-4
SI-5
SS-1
20°N
12°N
64°O
56°O


incremental freq. (yr-1)
cummulative freq. (yr-1)
magnitude
SS-2
SS-3
SS-4
PRM
NMS
MS
SMS
20°N
64°O
56°O
12°N

S3 Extension rate and b-value vs Mmin

Sensitivity analysis of the minimum magnitude (Mmin) impact on the calculated extension rate (V. Normal) and Gutenberg-Richter b-value in the FA-2 (Marie-Galante graben) seismogenic source, using the ISCU-cat and Mmax.struct (**S2**). NB: b-value ≥ 1.5 is not accepted in the method.



S4 Geodetic 2D modelling

Vertical (Vz) and horizontal (Vx, in the profile direction) velocities from GNSS (blue square) and micro-atoll (red square) data compared to predictions from 2D models of subduction interface interseismic coupling for a cross section at the latitude of Guadeloupe. Three cases are considered: interseismic coupling of the upper part of the interface (Up, 0-40 km depth), interseismic coupling of the deep part (Down, 40-90 km depth), and interseismic coupling of the entire interface (All). Micro-atoll and GNSS data are from Philibosian et al. (2022) and van Rijsingen et al. (2021).