Electronic Supplement.

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Synthetic Grid

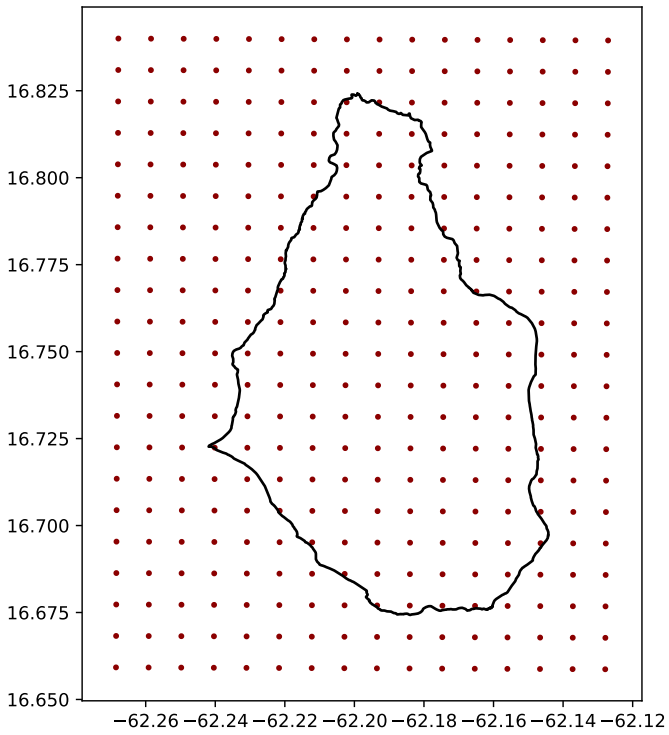

Figure S1: Location of the synthetic earthquakes used for calculating synthetic travel times: synthetic earthquakes are spaced 1 km apart and cover a 15 by 20 km grid. Synthetic earthquakes were at depths of 0.5 km abs, 0,1,3,5,5.8 and 10 km bsl.

Seismic Stations Present

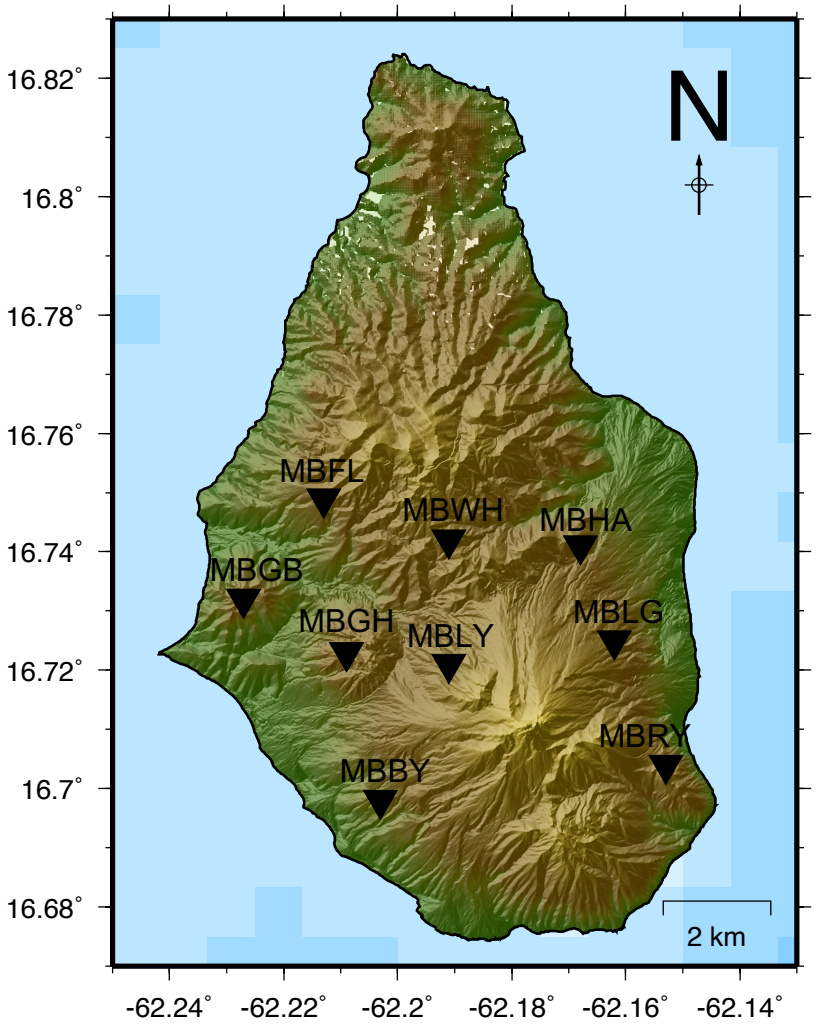

Figure S2: Location of seismic stations active during February 2020; these were used for relocating synthetic earthquakes during the method comparison.

Table S1: Seismic stations active during February 2020; these were used for relocating synthetic earthquakes during the method comparison.

Name	**Latitude**	**Longitude**	**Elevation (m)**
MBFL	16.749	-62.213	243
MBGB	16.732	-62.228	253
MBGH	16.723	-62.209	350
MBLY	16.721	-62.191	355
MBBY	16.698	-62.203	161
MBWH	16.742	-62.191	407
MBHA	16.741	-62.168	250
MBLG	16.725	-62.162	287
MBRY	16.704	-62.153	355

Station Comparison

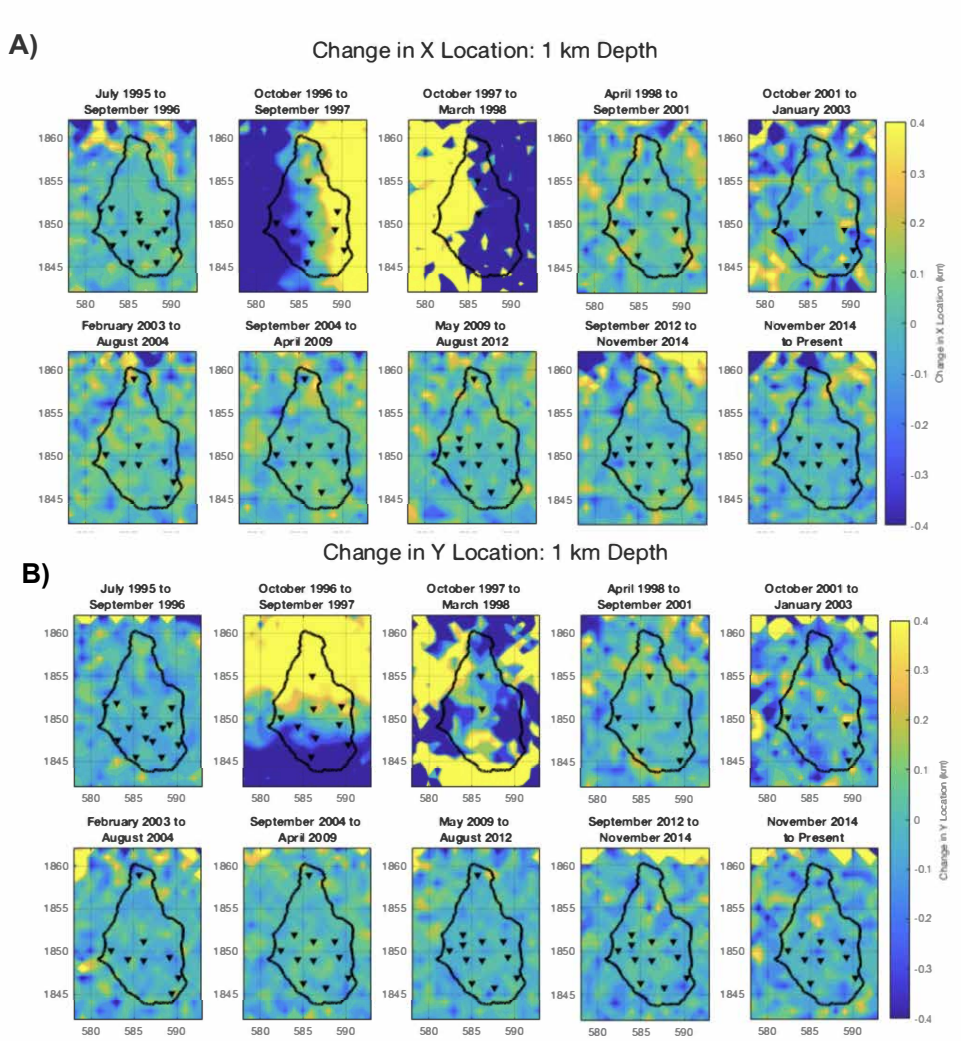

Figure S3: Comparison of different station configurations with synthetic earthquakes at 1 km depth for the Change in X and Y location. Tested using the *Rowe et al.* (2004) velocity model with NonLinLoc.

Pick Error Testing

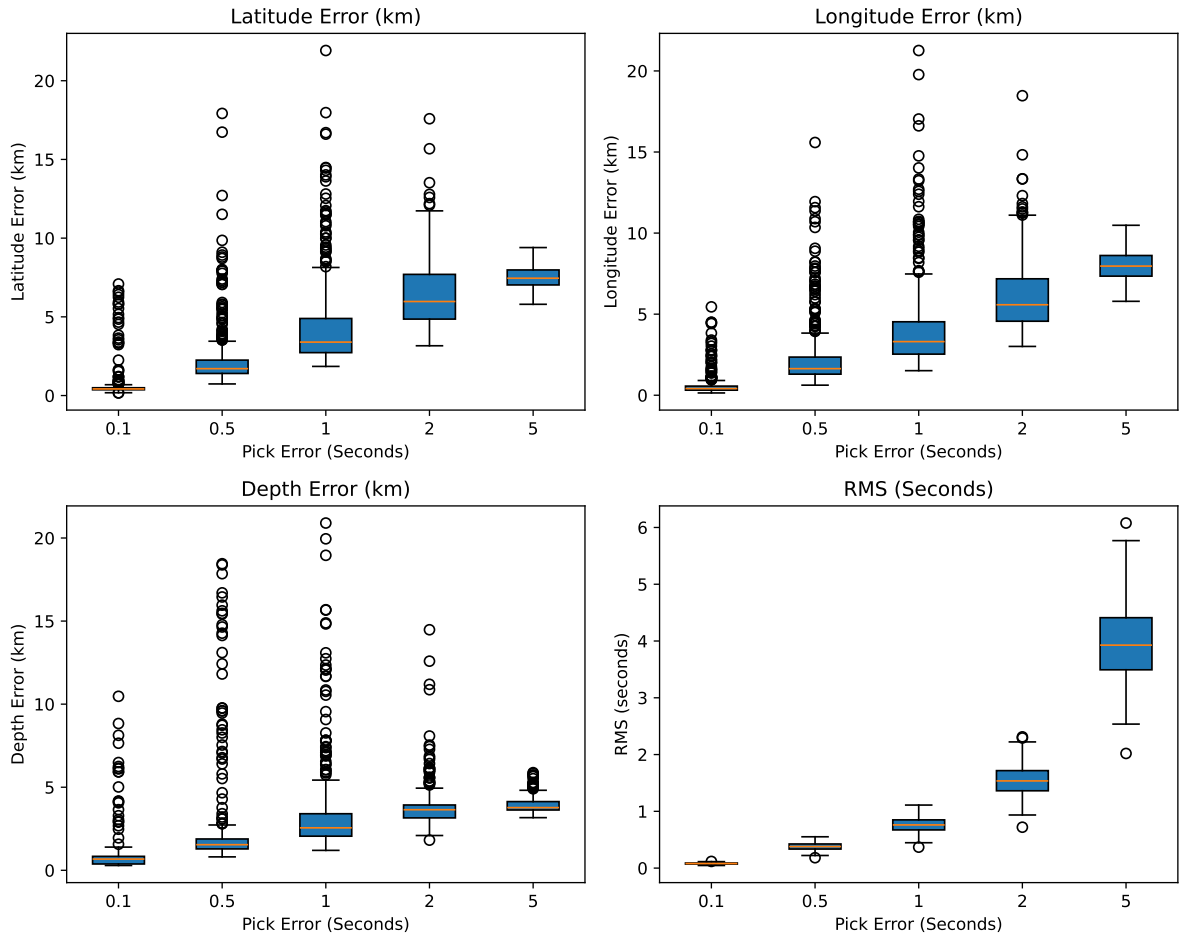

Figure S4: Boxplot showing the comparison of hypocenter error with different P and S wave pick errors for synthetic testing. Tested using the *Rowe et al.* (2004) velocity model with NonLinLoc. Orange line represents median value, edge of blue box represent 25th and 75th percentile, and the black line represents the full range in values with circles representing outliers.

Velocity Models

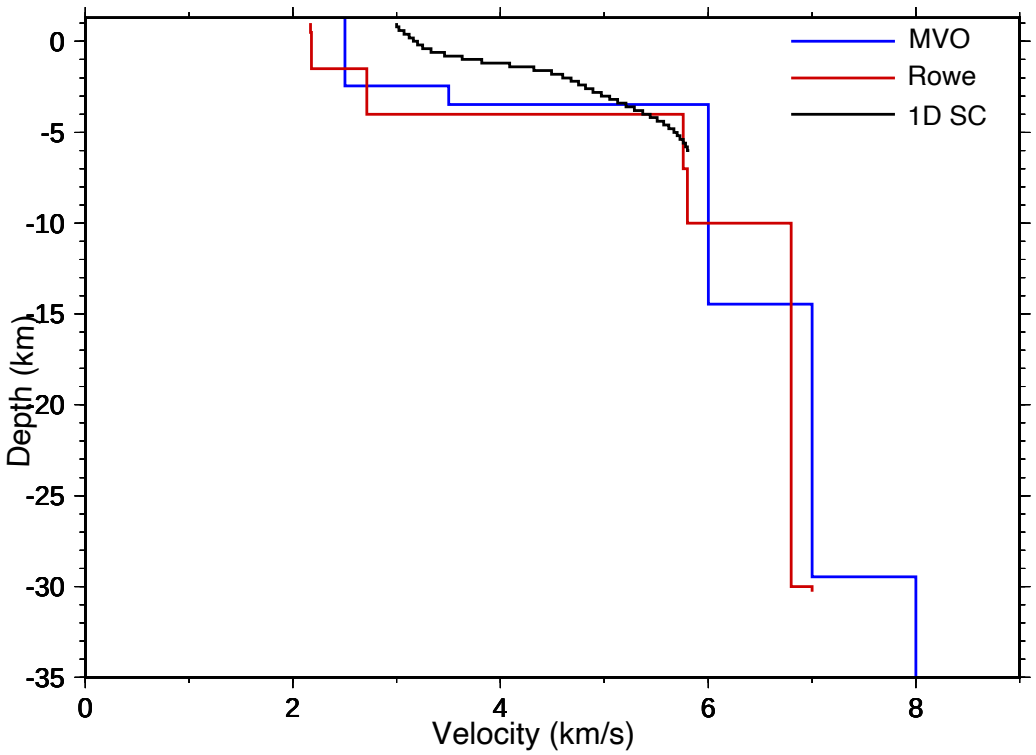

Figure S5: P wave seismic velocities for the three different 1D seismic velocity models tested. Blue line represents the velocity model used by the Montserrat Volcano Observatory in 2022. The red line is the velocity model proposed by *Rowe et al.* (2004), and the black line is the 1D velocity model created from the SEA-CALIPSO project in 2007 (*Shalev et al.*, 2010)

Synthetic Testing Results

		Method 1			Method 2				Method 3				Method 4			
		V1	V2	V3	V1	V2	V3	V4	V1	V2	V3	V4	V1	V2	V3	V4
0.5hkm	x	86.9	10.4	55.1	84.5	82.4	84.8	65.2	88.7	88.4	91.4	86.6	82.4	82.7	84.2	64.3
	y	92.9	14.9	51.8	81.8	82.7	79.2	58.6	87.5	89.3	85.7	84.5	80.4	81.3	78.6	59.5
	z	86.9	10.4	55.1	84.5	82.4	84.8	65.2	88.7	88.4	91.4	86.6	82.4	82.7	84.2	64.3
0km	x	83.6	11.0	37.2	83.6	83.6	82.4	66.7	87.5	89.9	89.3	88.1	82.1	82.1	81.5	66.7
	y	95.5	14.6	45.8	80.7	81.3	75.9	61.0	85.7	86.6	81.8	86.9	80.4	80.1	75.6	61.3
	z	39.0	18.5	10.4	70.2	72.9	78.0	17.0	77.7	78.6	83.9	93.8	68.8	1.5	78.3	17.0
1km	x	78.9	11.6	28.0	81.3	82.4	79.5	65.5	86.9	90.8	88.1	91.7	79.8	81.5	77.4	64.6
	y	90.5	10.7	32.1	73.8	82.7	78.6	58.6	80.4	87.5	81.5	89.0	72.9	81.8	77.7	58.6
	z	25.6	14.6	10.1	77.1	84.8	73.5	11.3	84.2	89.9	80.1	86.0	76.8	84.8	74.1	10.7
3km	x	81.8	15.2	18.2	78.0	79.8	84.2	34.2	83.9	87.5	89.9	89.0	77.1	78.9	83.3	34.2
	y	75.3	5.4	21.1	74.7	69.3	83.3	26.8	78.0	76.2	89.3	88.1	74.1	69.0	82.1	25.9
	z	29.2	17.0	36.3	72.3	75.3	83.0	27.4	75.0	84.2	86.9	83.9	72.9	74.1	82.4	27.1
5km	x	73.5	13.4	16.4	77.4	77.4	84.8	25.9	83.3	82.4	89.0	88.4	76.2	76.5	83.6	25.6
	y	58.3	5.4	17.6	75.3	70.5	83.9	15.5	79.5	75.9	89.0	88.1	75.3	68.8	83.6	15.2
	z	63.1	21.1	62.8	55.1	48.2	75.6	38.7	57.7	50.9	84.5	78.9	56.0	47.9	75.9	37.8
5.8km	x	93.5	16.7	15.8	78.6	78.9	83.6	24.7	85.4	84.5	89.6	88.7	78.3	76.8	83.3	24.4
	y	78.3	5.4	15.8	76.2	73.8	83.9	17.6	82.1	80.4	89.9	86.3	77.1	74.7	83.9	16.4
	z	79.2	26.8	50.6	70.2	60.7	86.0	35.7	70.8	60.7	90.5	79.2	70.2	60.4	85.7	35.7
10km	x	95.2	17.0	X	83.3	85.4	X	22.3	89.6	88.7	X	89.9	81.8	84.5	X	22.3
	y	71.7	1.5	X	84.2	85.7	X	7.7	89.0	91.7	X	89.3	84.8	85.7	X	7.4
	z	84.2	6.5	X	86.9	86.9	X	94.0	95.5	95.5	X	93.5	86.6	85.7	X	93.8

Figure S6: Figure shows the percentage of trusted earthquakes for the X,Y,Z location, for each velocity model and location method. Orange shows percentages higher than 60%, yellow higher than 70%, light green higher than 80% and dark green higher than 85%. The red outlined cells show the best velocity model/location method for that depth. V1: MVO velocity model, V2: *Rowe et al.* (2004) velocity model, V3: 1D SEA-CALIPSO model by *Shalev et al.* (2010); V4: 3D SEA-CALIPSO model by *Paulatto et al.* (2012). Method 1: *Hypocenter* with settings used by MVO, Method 2: *NonLinLoc* with the Gaussian Inversion, Method 3: *NonLinLoc* with the EDT method, Method 4: *NonLinLoc* with the Gaussian Inversion and equally weighted stations.

		0.5hkm				0km				1km				3km				5km				5.8km				10km			
		V1	V2	V3	V4	V1	V2	V3	V4	V1	V2	V3	V4	V1	V2	V3	V4	V1	V2	V3	V4	V1	V2	V3	V4	V1	V2	V3	V4
RMS (s)	Method 1	0.09	0.79	0.12	X	0.10	0.75	0.13	X	0.09	0.59	0.14	X	0.10	0.30	0.15	X	0.09	0.15	0.15	X	0.09	0.15	0.15	X	0.09	0.15	X	X
	Method 2	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.10	0.09	0.09	0.09	0.10	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	X	0.12
	Method 3	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	X	0.08
	Method 4	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.10	0.09	0.09	0.09	0.10	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	X	0.12
Loc X (km)	Method 1	0.38	143.96	0.94	X	0.40	142.56	8.54	X	0.46	139.32	7.86	X	0.64	131.53	6.61	X	0.90	123.79	5.51	X	0.57	122.52	2.22	X	0.60	112.57	X	X
	Method 2	0.19	0.15	0.21	0.43	0.23	0.18	0.23	0.41	0.29	0.21	0.25	0.50	0.34	0.28	0.22	1.02	0.34	0.32	0.25	1.46	0.33	0.31	0.26	1.58	0.36	0.33	X	2.56
	Method 3	0.20	0.14	0.22	0.37	0.23	0.19	0.24	0.37	0.30	0.20	0.25	0.28	0.34	0.28	0.23	0.28	0.34	0.33	0.26	0.30	0.34	0.32	0.27	0.32	0.37	0.34	X	0.43
	Method 4	0.19	0.15	0.21	0.43	0.23	0.18	0.24	0.41	0.29	0.21	0.25	0.50	0.35	0.28	0.22	1.02	0.33	0.32	0.25	1.46	0.33	0.31	0.26	1.58	0.36	0.33	X	2.57
Loc Y (km)	Method 1	0.54	137.58	1.62	X	0.94	137.88	1.86	X	1.05	139.58	2.29	X	1.08	144.93	2.80	X	1.76	151.86	3.16	X	0.73	153.68	3.26	X	0.83	169.66	X	X
	Method 2	0.27	0.17	0.27	0.61	0.33	0.23	0.30	0.62	0.45	0.28	0.30	0.64	0.48	0.40	0.24	1.15	0.50	0.49	0.29	1.74	0.49	0.45	0.30	1.91	0.48	0.40	X	3.61
	Method 3	0.27	0.15	0.28	0.46	0.34	0.24	0.31	0.42	0.46	0.27	0.31	0.30	0.49	0.40	0.24	0.27	0.51	0.49	0.29	0.31	0.49	0.46	0.30	0.33	0.48	0.40	X	0.45
	Method 4	0.27	0.17	0.27	0.61	0.33	0.23	0.30	0.60	0.45	0.28	0.30	0.64	0.48	0.40	0.24	1.16	0.50	0.49	0.29	1.74	0.48	0.44	0.30	1.91	0.47	0.40	X	3.65
Loc Z (km)	Method 1	0.51	0.74	4.45	X	2.94	0.65	4.19	X	3.46	1.36	3.35	X	3.84	3.22	1.81	X	1.96	5.16	0.98	X	1.43	5.89	0.94	X	1.01	9.44	X	X
	Method 2	0.47	0.29	0.31	0.44	0.54	0.32	0.34	0.39	0.59	0.28	0.45	0.75	0.81	0.58	0.43	1.25	1.06	0.95	0.46	1.49	1.01	0.98	0.29	1.66	0.52	0.43	X	0.35
	Method 3	0.46	0.28	0.32	0.10	0.52	0.31	0.35	0.11	0.61	0.27	0.45	0.31	0.82	0.57	0.44	0.45	1.06	0.97	0.46	0.61	1.02	1.00	0.29	0.65	0.53	0.44	X	0.35
	Method 4	0.47	0.30	0.31	0.44	0.54	0.32	0.34	0.38	0.59	0.28	0.45	0.75	0.80	0.58	0.43	1.24	1.05	0.95	0.46	1.48	0.99	0.98	0.29	1.66	0.51	0.43	X	0.35

Figure S7: Figure shows mean RMS and change in X, Y and Z location of the 336 relocated earthquakes for each relocation when using synthetic earthquakes. Green cells highlight lowest value for that depth and variable (Note: values are rounded for 2 decimal places, cells were highlighted before rounding). V1: MVO velocity model, V2: *Rowe et al.* (2004) velocity model, V3: 1D SEA-CALIPSO model by *Shalev et al.* (2010); V4: 3D SEA-CALIPSO model by *Paulatto et al.* (2012). Method 1: *Hypocenter* with settings used by MVO, Method 2: *NonLinLoc* with the Gaussian Inversion, Method 3: *NonLinLoc* with the EDT method, Method 4: *NonLinLoc* with the Gaussian Inversion and equally weighted stations.

		0.5hkm				0km				1km				3km				5km				5.8km				10km			
		V1	V2	V3	V4	V1	V2	V3	V4	V1	V2	V3	V4	V1	V2	V3	V4	V1	V2	V3	V4	V1	V2	V3	V4	V1	V2	V3	V4
Error X (km)	Method 1	1.21	51.38	0.66	X	1.25	52.80	0.66	X	1.22	48.24	0.64	X	1.96	49.28	0.64	X	2.17	39.08	0.66	X	1.63	42.38	0.68	X	1.60	40.78	X	X
	Method 2	0.29	0.24	0.36	0.50	0.31	0.26	0.38	0.51	0.35	0.30	0.40	0.61	0.48	0.39	0.42	0.63	0.49	0.46	0.45	0.70	0.50	0.47	0.47	0.74	0.63	0.59	X	1.02
	Method 3	0.34	0.29	0.43	0.65	0.36	0.32	0.45	0.68	0.41	0.35	0.46	0.55	0.56	0.47	0.49	0.55	0.56	0.53	0.54	0.61	0.58	0.55	0.56	0.64	0.77	0.72	X	0.90
	Method 4	0.28	0.23	0.35	0.49	0.30	0.26	0.37	0.51	0.34	0.29	0.39	0.61	0.47	0.38	0.41	0.62	0.48	0.45	0.44	0.69	0.49	0.46	0.46	0.73	0.62	0.58	X	0.99
Error Y (km)	Method 1	1.40	51.46	0.91	X	1.46	52.86	0.91	X	1.39	48.26	0.92	X	1.93	49.30	0.93	X	1.97	39.10	0.95	X	1.45	42.39	0.96	X	1.14	40.77	X	X
	Method 2	0.35	0.26	0.38	0.58	0.38	0.30	0.40	0.61	0.41	0.34	0.43	0.69	0.54	0.43	0.45	0.67	0.58	0.52	0.49	0.73	0.61	0.55	0.52	0.78	0.84	0.76	X	1.04
	Method 3	0.41	0.33	0.44	0.76	0.44	0.37	0.47	0.79	0.46	0.39	0.49	0.58	0.62	0.50	0.53	0.53	0.66	0.60	0.60	0.61	0.70	0.63	0.64	0.65	1.03	0.93	X	0.97
	Method 4	0.34	0.26	0.37	0.58	0.38	0.30	0.39	0.60	0.40	0.33	0.42	0.68	0.53	0.43	0.44	0.66	0.57	0.52	0.48	0.72	0.60	0.54	0.51	0.77	0.84	0.75	X	1.02
Error Z (km)	Method 1	1.78	1.47	1.14	X	1.60	1.72	1.01	X	0.76	1.35	0.91	X	1.16	1.59	0.90	X	2.43	1.98	0.89	X	2.40	2.54	0.88	X	2.14	2.22	X	X
	Method 2	0.52	0.34	0.41	0.15	0.57	0.39	0.49	0.18	0.51	0.35	0.59	0.34	0.73	0.44	0.75	0.67	0.90	0.78	0.68	1.05	0.98	0.86	0.60	1.17	1.28	1.25	X	1.28
	Method 3	0.60	0.41	0.50	0.20	0.64	0.46	0.59	0.34	0.60	0.44	0.69	0.57	0.82	0.53	0.86	0.79	0.96	0.83	0.84	0.95	1.06	0.92	0.77	1.01	1.65	1.56	X	1.18
	Method 4	0.52	0.34	0.41	0.15	0.57	0.39	0.49	0.18	0.51	0.35	0.58	0.33	0.73	0.44	0.74	0.67	0.90	0.77	0.68	1.04	0.98	0.85	0.59	1.16	1.27	1.24	X	1.27

Figure S8: Figure shows mean error of the 336 relocated earthquakes for each relocation when using synthetic earthquakes. V1: MVO velocity model, V2: *Rowe et al.* (2004) velocity model, V3: 1D SEA-CALIPSO model by *Shalev et al.* (2010); V4: 3D SEA-CALIPSO model by *Paulatto et al.* (2012). Method 1: *Hypocenter* with settings used by MVO, Method 2: *NonLinLoc* with the Gaussian Inversion, Method 3: *NonLinLoc* with the EDT method, Method 4: *NonLinLoc* with the Gaussian Inversion and equally weighted stations.

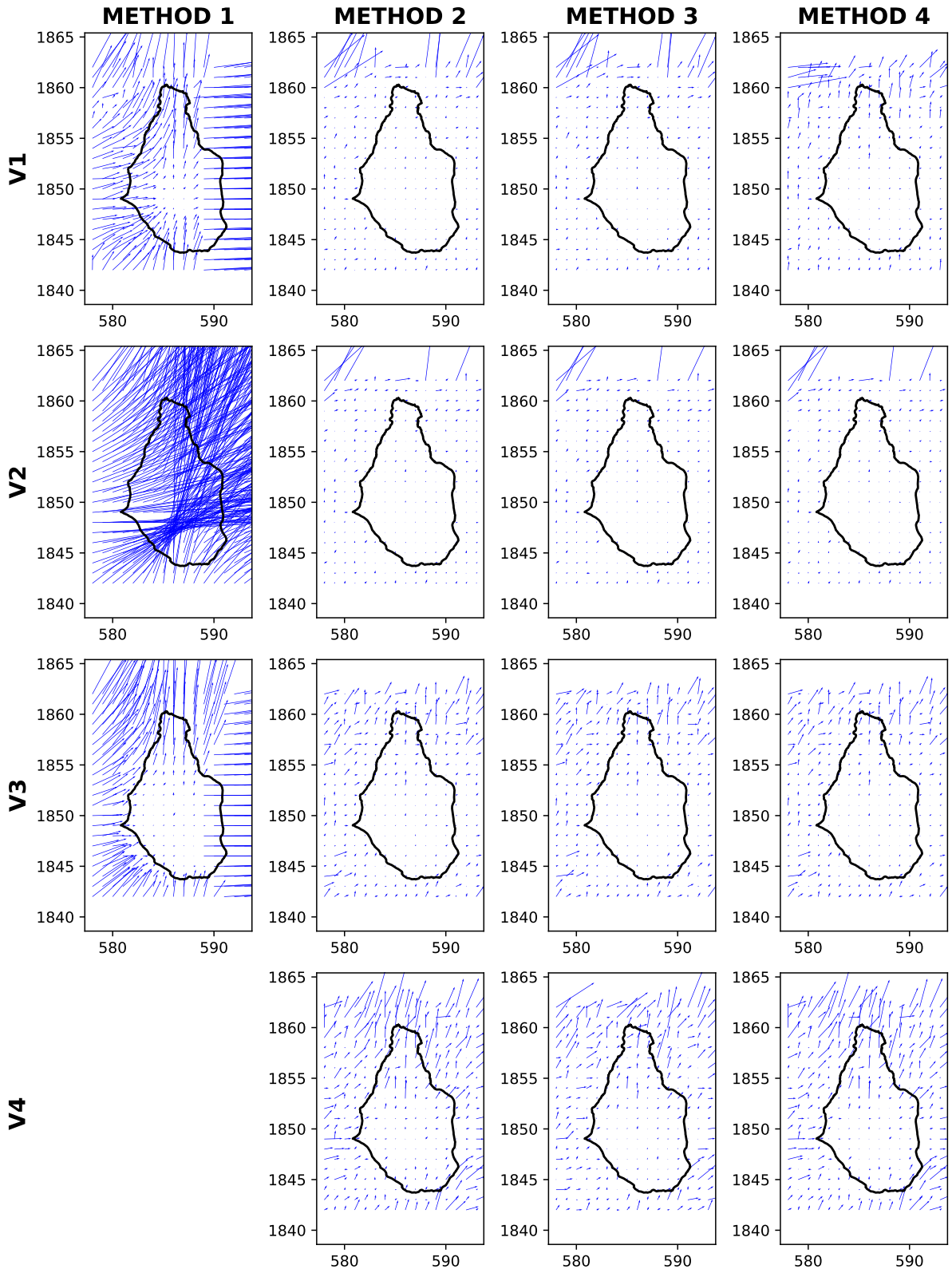

Figure S9: Vector plot showing the change in location of the 336 relocated earthquakes for each synthetic earthquakes when using each velocity model and location method. Vector length represents the change in location in metres (in the same scale as the X and Y axis). V1: MVO velocity model, V2: *Rowe et al.* (2004) velocity model, V3: 1D SEA-CALIPSO model by *Shalev et al.* (2010); V4: 3D SEA-CALIPSO model by *Paulatto et al.* (2012). Method 1: *Hypocenter* with settings used by MVO, Method 2: *NonLinLoc* with the Gaussian Inversion, Method 3: *NonLinLoc* with the EDT method, Method 4: *NonLinLoc* with the Gaussian Inversion and equally weighted stations.

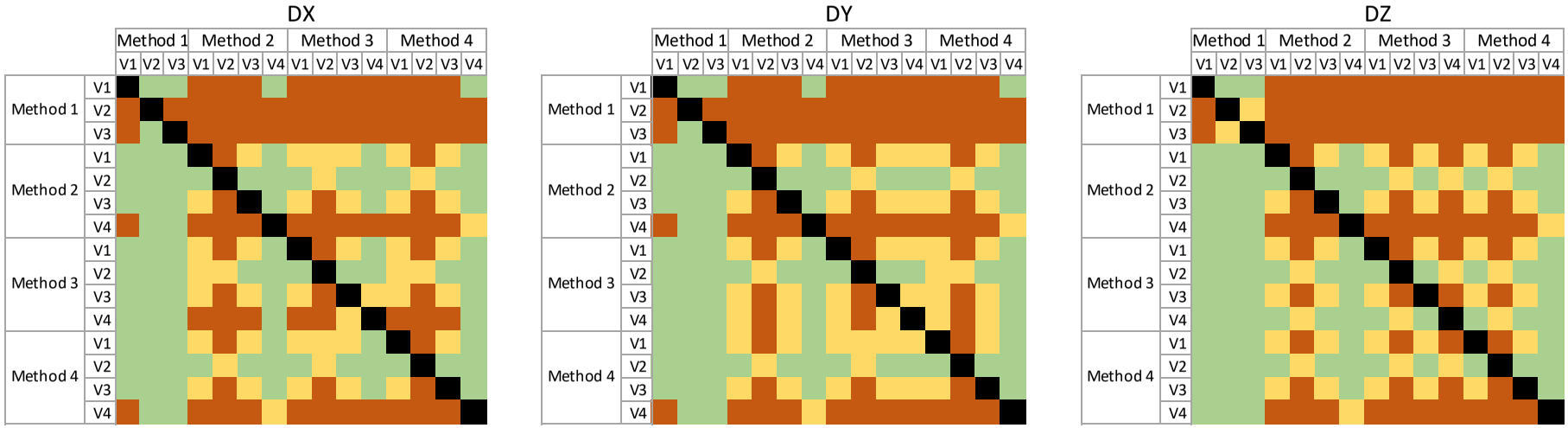

Figure S10: Significance checkerboards showing if different runs are more or less significant than other runs. DX – Change in X location; DY – Change in Y location; DZ – Change in Z location. To be read down (Y) and then across (X) when interpreting. Green represents Y is significantly less than X, Orange represents Y is significantly greater than X, and yellow means there is no statistical significance between the two runs. V1: MVO velocity model, V2: *Rowe et al.* (2004) velocity model, V3: 1D SEA-CALIPSO model by *Shalev et al.* (2010); V4: 3D SEA-CALIPSO model by *Paulatto et al.* (2012). Method 1: *Hypocenter* with settings used by MVO, Method 2: *NonLinLoc* with the Gaussian Inversion, Method 3: *NonLinLoc* with the EDT method, Method 4: *NonLinLoc* with the Gaussian Inversion and equally weighted stations.

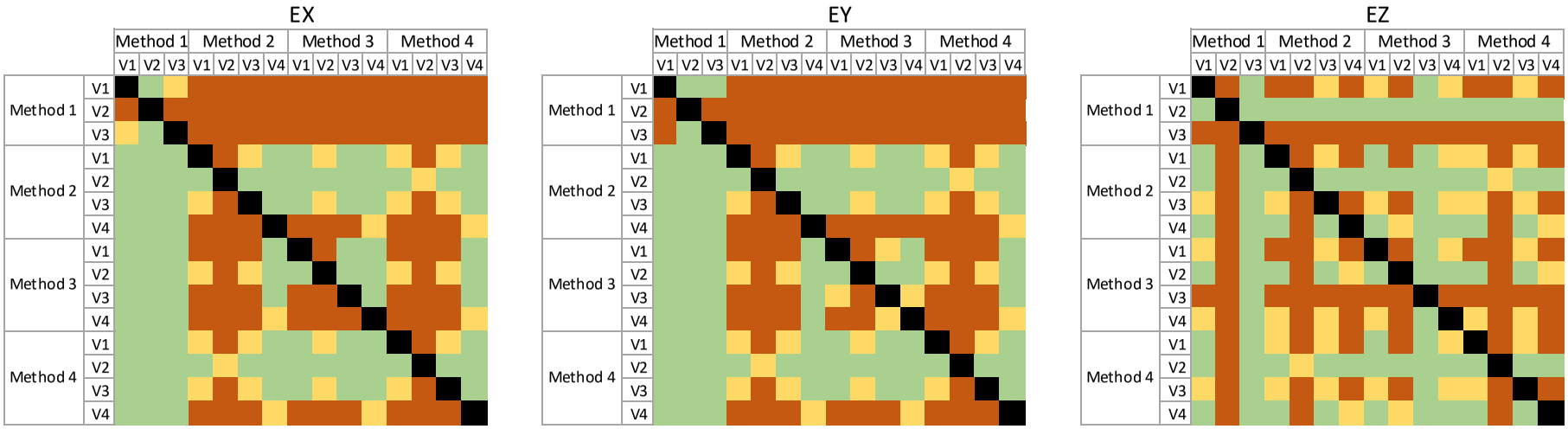

Figure S11: Significance checkerboards showing if different runs are more or less significant than other runs. EX – Error in X location; EY – Error in Y location; EZ – Error in Z location. To be read down (Y) and then across (X) when interpreting. Green represents Y is significantly less than X, Orange represents Y is significantly greater than X, and yellow means there is no statistical significance between the two runs. V1: MVO velocity model, V2: *Rowe et al.* (2004) velocity model, V3: 1D SEA-CALIPSO model by *Shalev et al.* (2010); V4: 3D SEA-CALIPSO model by *Paulatto et al.* (2012). Method 1: *Hypocenter* with settings used by MVO, Method 2: *NonLinLoc* with the Gaussian Inversion, Method 3: *NonLinLoc* with the EDT method, Method 4: *NonLinLoc* with the Gaussian Inversion and equally weighted stations.

Comparison with *Roman et al.* (2008)

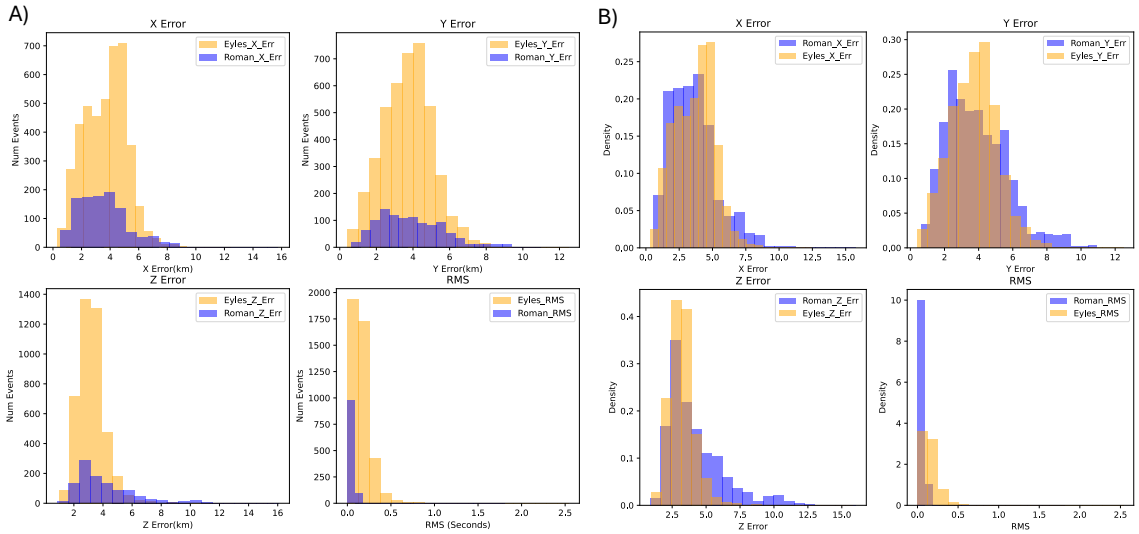

Figure S12: Comparison of Hypocenter Error between locations using *Roman et al.* (2008) picks and picks from MVO's catalogue. A) represents histogram for all events from July to December 1995. B) shows a density histogram from July to December 1995 to account for less events.

Seismic Stations in 1995

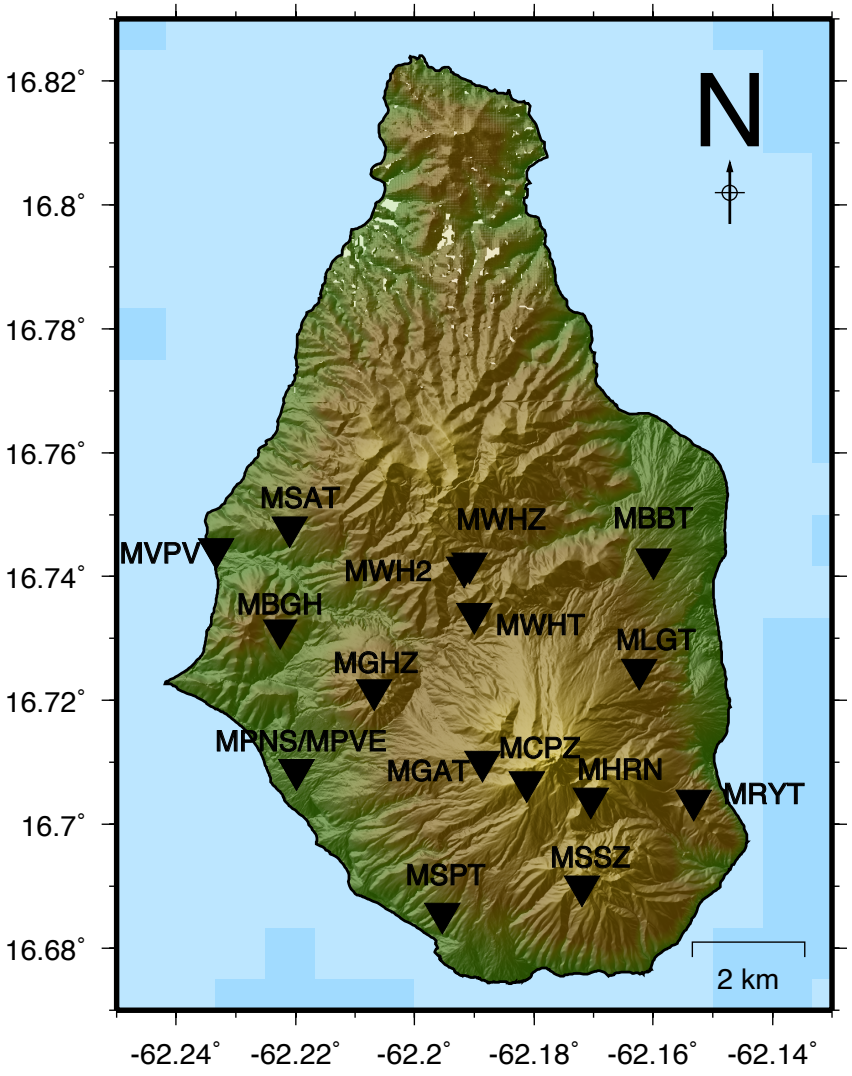

Figure S13: Location of seismic stations active during July–November 1995; these were used for relocating earthquakes during this time frame.

Table S2: Seismic stations active from July 1995 to November 1995; these stations were used for relocation of the seismic catalogue during this time frame.

Name	**Latitude**	**Longitude**	**Elevation (m)**
MGHZ	16.722	-62.207	351
MSPT	16.686	-62.195	108
MGAT	16.710	-62.189	479
MRYT	16.704	-62.153	355
MLGT	16.725	-62.162	287
MWHT	16.734	-62.190	350
MCPZ	16.707	-62.181	759
MHRN	16.704	-62.171	382
MPNS	16.709	-62.220	20
MVPV	16.745	-62.233	20
MPVE	16.709	-62.220	20
MSSZ	16.690	-62.172	762
MWH2	16.742	-62.192	337
MWHZ	16.742	-62.191	407
MBET	16.743	-62.160	100
MSAT	16.748	-62.221	195

Earthquake Locations

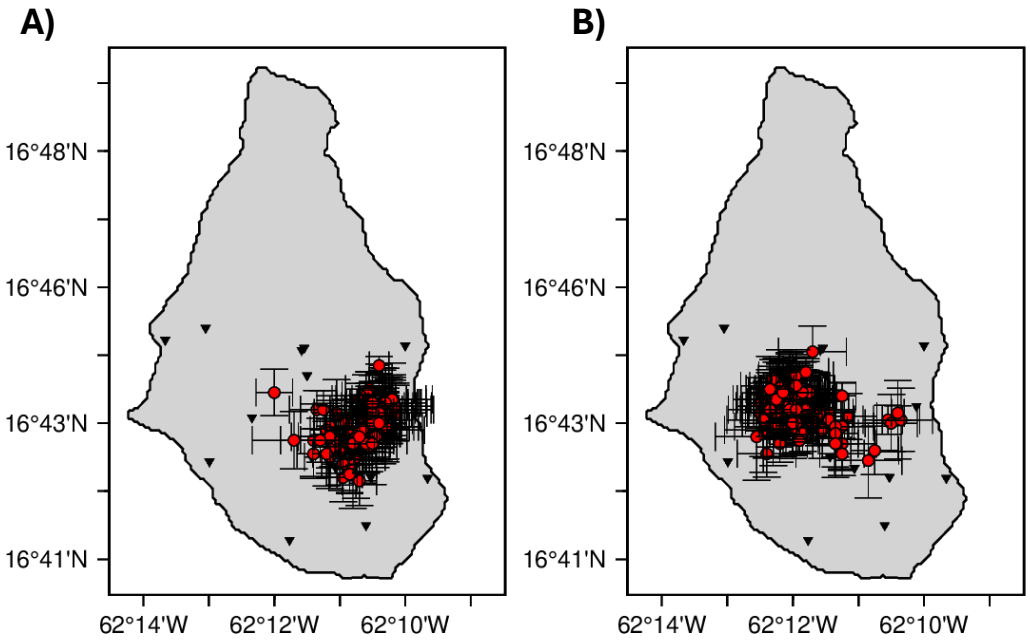

Figure S14: A) Location and associated errors for earthquakes recorded during the NE cluster. B) Location and associated errors for earthquakes recorded during the SGH cluster.

Earthquake Catalogue Data

The complete catalogue of earthquake locations has been attached as a csv file under the name: 'Catalogue Data.csv'. The catalogue includes all earthquakes located from July-December 1995 inclusive, before filtering for hypocenteral error, RMS and azimuthal gap. This data is currently being uploaded to the NGDC repository, and if accepted a DOI number will be provided for this datasource.

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