

Supplementary Information

Sensor Orientation of the TMD Seismic Network (Thailand) from P-Wave Particle Motions

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Table S1 Seismometer orientation result and station details, including earthquake events using in analysis of 45 surface stations

Station name	Component name	Equipment Type	Lat. (°)	Long. (°)	Estimate period	Orientation result (°)	Orientation from North* (°)	Number of earthquakes	Passed Quality Control
CHAI	SHZ, SHN, SHE	1	15.9018	101.9864	2009 - 2019	4.7 ±13.2	5	893	327
	EHZ, EHN, EHE	5			2020 - 2022	352.6 ±4.0	-7	199	96
CHBT	BHZ, BHN, BHE	4	12.7442	102.3527	2009 - 2019	359.3 ±2.9	-1	446	139
	HHZ, HHN, HHE	6			2020 - 2022	357.3 ±3.4	-3	182	109
CMAI	BHZ, BHN, BHE	2	19.9325	99.0453	2009 - 2017	358.6 ±1.2	-1	336	160
	HHZ, HHN, HHE	6			2018 - 2021	0.6 ±1.7	1	314	207
CMMT	BHZ, BHN, BHE	4	18.8138	98.9443	2009 - 2017	1.5 ±0.9	1	796	570
	HHZ, HHN, HHE	6			2018 - 2021	3.1 ±3.2	3	153	106
CRAI	BHZ, BHN, BHE	2	20.2289	100.3734	2009 - 2019	0.1 ±1.9	0	770	265
	HHZ, HHN, HHE	6			2020 - 2022	1.2 ±2.5	1	261	173
HOTB	HHZ, HHN, HHE	6	18.1922	98.6103	2018 - 2021	336.3 ±1.7	-24	437	285
KHLT	CHZ, CHN, CHE	3	14.7970	98.5893	2009 - 2017	1.1 ±3.8	1	201	99
	HHZ, HHN, HHE	6			2018 - 2021	359.3 ±2.1	-1	439	247
KHOB	HHZ, HHN, HHE	6	18.0265	101.0689	2018 - 2021	356.8 ±2.3	-3	378	218
KHON	SHZ, SHN, SHE	1	16.3378	102.8230	2009 - 2017	6.4 ±2.5	6	733	222
	EHZ, EHN, EHE	5			2020 - 2022	5.7 ±4.4	6	201	72
KRAB	SHZ, SHN, SHE	1	8.2215	99.1965	2009 - 2017	358.0 ±23.7	-2	663	19
	EHZ, EHN, EHE	5			2020 - 2022	4.6 ±22.6	5	199	22
KRAU	HHZ, HHN, HHE	6	16.8838	101.8846	2018 - 2021	358.8 ±2.0	-1	247	163
KRDT	CHZ, CHN, CHE	3	14.5906	101.8442	2009 - 2017	5.9 ±4.7	6	635	258
	EHZ, EHN, EHE	5			2020 - 2022	356.2 ±8.7	-4	200	43
LAMP	SHZ, SHN, SHE	1	18.5226	99.6323	2009 - 2017	356.2 ±1.5	-4	761	372
	HHZ, HHN, HHE	6			2018 - 2022	359.8 ±1.4	0	442	332

Station name	Component name	Equipment Type	Lat. (°)	Long. (°)	Estimate period	Orientation result (°)	Orientation from North* (°)	Number of earthquakes	Passed Quality Control
LOEI	BHZ, BHN, BHE	2	17.5093	101.2644	2009 - 2017	23.8 ±3.7	24	675	133
	HHZ, HHN, HHE	6			2020 - 2022	18.4 ±1.5	18	208	137
MHIT	BHZ, BHN, BHE	4	19.3149	97.9632	2009 - 2017	25.5 ±12.9	26	666	320
	HHZ, HHN, HHE	6			2020 - 2022	1.6 ±2.8	2	193	113
MHMT	CHZ, CHN, CHE	3	18.1764	97.9310	2009 - 2017	349.4 ±2.3	-11	542	277
	HHZ, HHN, HHE	5			2018 - 2021	356.1 ±8.0	-4	396	70
NAN	SHZ, SHN, SHE	1	19.2835	100.9116	2009 - 2017	358.0 ±4.4	-2	815	330
	EHZ, EHN, EHE	5			2020 - 2022	346.0 ±10.8	-14	139	66
NAYO	BHZ, BHN, BHE	2	14.3152	101.3209	2009 - 2017	3.7 ±1.8	4	518	146
	HHZ, HHN, HHE	6			2020 - 2022	359.2 ±1.6	-1	180	123
NONG	BHZ, BHN, BHE	2	18.0635	103.1457	2009 - 2017	10.7 ±3.0	11	812	220
	HHZ, HHN, HHE	6			2020 - 2022	1.9 ±1.9	2	196	119
PANO	BHZ, BHN, BHE	2	17.1476	104.6122	2009 - 2017	354.0 ±29.2	-6	336	69
	HHZ, HHN, HHE	5			2018 - 2021	31.1 ±3.5	31	433	167
PATY	SHZ, SHN, SHE	1	12.9232	100.8657	2009 - 2017	2.0 ±1.6	2	782	369
	EHZ, EHN, EHE	5			2020 - 2022	4.6 ±3.0	5	193	83
PAYA	SHZ, SHN, SHE	1	19.3603	99.8692	2009 - 2017	344.6 ±8.5	-15	754	250
	EHZ, EHN, EHE	5			2020 - 2022	9.4 ±3.5	9	178	79
PBKT	BHZ, BHN, BHE	4	16.5735	100.9688	2009 - 2017	0.4 ±0.9	0	682	356
	HHZ, HHN, HHE	6			2020 - 2022	9.7 ±1.6	10	195	132
PHET	SHZ, SHN, SHE	1	12.9133	99.6268	2009 - 2017	358.1 ±3.2	-2	676	318
	EHZ, EHN, EHE	5			2020 - 2022	351.2 ±8.1	-9	194	102
PHIT	SHZ, SHN, SHE	1	17.1893	100.4165	2009 - 2017	347.9 ±4.6	-12	545	175
	EHZ, EHN, EHE	5			2020 - 2022	358.0 ±2.7	-2	200	95
PHRA	BHZ, BHN, BHE	2	18.4989	100.2293	2009 - 2014	206.5 ±3.6	-154	206	77
					2015 - 2017	11.8 ±2.4	12	175	75
	HHZ, HHN, HHE	6			2020 - 2022	157.5 ±3.1	157	189	110
PKDT	CHZ, CHN, CHE	3	7.8914	98.3344	2009 - 2017	354.6 ±0.8	-5	821	493
	EHZ, EHN, EHE	5			2020 - 2022	1.6 ±2.5	2	184	92
PRAC	BHZ, BHN, BHE	2	12.4726	99.7929	2009 - 2017	14.3 ±1.3	14	788	146
	HHZ, HHN, HHE	6			2020 - 2022	12.3 ±1.8	12	197	123
RNTT	CHZ, CHN, CHE	3	9.3904	98.4778	2009 - 2017	14.6 ±3.8	15	210	101
	HHZ, HHN, HHE	6			2018 - 2021	12.8 ±1.3	13	425	209
SKLT	BHZ, BHN, BHE	4	7.1758	100.6156	2009 - 2017	4.1 ±1.0	4	515	349
	HHZ, HHN, HHE	6			2020 - 2022	1.8 ±1.5	2	217	151
SKNT	CHZ, CHN, CHE	3	16.9740	103.9811	2009 - 2017	356.1 ±1.6	-4	486	271
	EHZ, EHN, EHE	5			2020 - 2022	355.0 ±6.6	-5	162	35
SRAK	SHZ, SHN, SHE	1	14.0120	102.6426	2009 - 2017	1.5 ±6.9	2	610	214
	EHZ, EHN, EHE	5			2020 - 2022	4.1 ±11.1	4	200	59
SRDT	BHZ, BHN, BHE	4	14.3948	99.1213	2009 - 2017	3.4 ±0.8	3	816	466
	HHZ, HHN, HHE	6			2020 - 2022	3.2 ±1.7	3	200	132
SRIT	BHZ, BHN, BHE	2	8.5955	99.6020	2009 - 2017	341.5 ±2.0	-19	602	157
	HHZ, HHN, HHE	6			2020 - 2022	350.3 ±1.9	-10	200	129
SUAB	HHZ, HHN, HHE	6	19.6611	99.5346	2018 - 2021	359.3 ±2.0	-1	341	132

Station name	Component name	Equipment Type	Lat. (°)	Long. (°)	Estimate period	Orientation result (°)	Orientation from North* (°)	Number of earthquakes	Passed Quality Control
SUKH	SHZ, SHN, SHE	1	17.4821	99.6310	2009 - 2017	357.7 ±2.0	-2	465	220
	EHZ, EHN, EHE	5			2020 - 2022	26.1 ±16.0	26	189	38
SURA	BHZ, BHN, BHE	2	9.1663	99.6295	2009 - 2017	350.5 ±21.9	-10	589	95
	HHZ, HHN, HHE	6			2020 - 2022	2.3 ±1.6	2	194	129
SURI	SHZ, SHN, SHE	1	14.7688	103.5529	2009 - 2015	10.2 ±1.3	10	666	313
	EHZ, EHN, EHE	5			2020 - 2022	11.4 ±3.6	11	91	50
SURT	CHZ, CHN, CHE	3	8.9577	98.7951	2009 - 2015	1.4 ±1.4	1	654	167
	EHZ, EHN, EHE	5			2020 - 2022	359.4 ±2.6	-1	194	96
TRTT	CHZ, CHN, CHE	3	7.8363	99.6913	2009 - 2015	344.4 ±1.6	-16	602	382
	EHZ, EHN, EHE	5			2020 - 2022	347.8 ±3.5	-12	201	117
TSYB	HHZ, HHN, HHE	6	17.2275	98.2255	2018 - 2022	344.7 ±1.7	-15	408	216
UBPT	BHZ, BHN, BHE	4	15.2773	105.4695	2009 - 2015	23.3 ±1.2	23	540	282
	HHZ, HHN, HHE	6			2020 - 2022	0.3 ±2.3	0	201	118
UMPA	SHZ, SHN, SHE	1	16.0257	98.8603	2009 - 2013	302.5 ±7.8	-58	396	210
	EHZ, EHN, EHE	5			2014 - 2017	3.0 ±2.3	3	392	136
					2020 - 2022	6.1 ±4.3	6	201	70
UTHA	SHZ, SHN, SHE	1	15.5586	99.4451	2009 - 2015	358.7 ±8.7	-1	705	438
	EHZ, EHN, EHE	5			2020 - 2022	23.5 ±3.4	24	202	108
UTTA	SHZ, SHN, SHE	1	17.7443	100.5541	2009 - 2015	353.7 ±2.6	-6	741	361
	EHZ, EHN, EHE	5			2020 - 2022	351.6 ±5.9	-8	174	76

- 1 Geotech S-13 (short-period) + Geotech Smart-24R
- 2 Geotech KS-2000 (Broadband) + Geotech Smart-24R
- 3 Nanometrics Trilium-40 (Broadband) + Nanometrics Taurus
- 4 Nanometrics Trilium-120 (Broadband) + Nanometrics Taurus
- 5 Guralp CMG-3ESP (1 sec) + Guralp Affinity
- 6 Guralp CMG-3T (120 sec) + Guralp Affinity

* Orientation from North (°) column represent a negative value means north (?HN) component orientate counterclockwise from true north and a positive value indicates north (?HN) orientate clockwise from true north, where original TMD metadata provide the orientation of north (?HN) component 0° from true north.

Table S2 Seismometer orientation result and station details of 26 borehole stations

Station name	Component name	Equipment Type	Lat. (°)	Long. (°)	Estimate period	Orientation result (°)	TMD metadata	Difference (°)	Number of earthquakes	Passed Quality Control
BKSI	HHZ, HHN, HHE	A	13.7263	100.5598	2020 - 2022	148.4 ±3.2	50.0	98	269	39
BUEN	HHZ, HHN, HHE	A	18.0454	104.1312	2018 - 2022	64.4 ±8.0	66.5	2	465	198
CHAC	HHZ, HHN, HHE	A	13.5675	101.4544	2018 - 2022	359.0 ±8.6	331.0	28	454	276
CHUM	EHZ, EHN, EHE	B	10.4980	99.1885	2018 - 2019	262.5 ±7.9	89.2	173	125	55
					2020 - 2022	200.6 ±7.0		111	134	54
CMPR	EHZ, EHN, EHE	B	19.3660	99.2022	2018 - 2022	62.2 ±4.5	243.0	179	483	204
CRMJ	HHZ, HHN, HHE	A	20.1266	99.8093	2018 - 2022	148.8 ±2.4	90.4	58	402	218
CRMM	HHZ, HHN, HHE	A	19.8494	100.1538	2018 - 2022	137.9 ±3.4	26.0	112	432	213
KAMP	EHZ, EHN, EHE	B	16.4864	99.5270	2018 - 2019	236.8 ±4.0	55.7	179	212	75
					2020 - 2022	126.3 ±8.2		71	234	93
KRAS	EHZ, EHN, EHE	B	8.1034	98.9755	2018 - 2022	6.5 ±14.1	188.5	178	397	51
KYAO	EHZ, EHN, EHE	B	8.0743	98.5848	2018 - 2022	1.5 ±3.6	180.3	179	464	165
LANT	HHZ, HHN, HHE	A	7.5448	99.0466	2018 - 2022	99.3 ±2.3	326.3	133	254	135
LPSP	EHZ, EHN, EHE	B	17.8754	99.3463	2018 - 2022	209.1 ±9.8	37.2	172	252	80
MUSE	EHZ, EHN, EHE	B	16.7523	98.9352	2018 - 2022	332.2 ±1.4	336.5	4	455	271
NANS	HHZ, HHN, HHE	A	18.8636	100.7418	2018 - 2022	246.4 ±8.0	50.0	164	467	187
NGLU	HHZ, HHN, HHE	A	15.1954	98.4612	2018 - 2022	24.9 ±1.3	336.1	49	425	184
OMKO	EHZ, EHN, EHE	B	17.7985	98.4329	2018 - 2022	250.4 ±1.5	76.9	174	360	251
PASO	HHZ, HHN, HHE	A	9.5220	99.1373	2018 - 2022	237.8 ±3.0	187.4	50	288	170
PHRS	HHZ, HHN, HHE	A	18.1289	100.1625	2018 - 2022	348.3 ±6.8	354.0	6	469	22
PNGA	HHZ, HHN, HHE	A	8.6839	98.2521	2018 - 2022	211.8 ±1.9	206.0	6	468	255
PRAS	EHZ, EHN, EHE	B	11.9385	99.6988	2018 - 2022	250.2 ±2.0	272.8	23	427	134
RATC	HHZ, HHN, HHE	A	13.4898	99.7926	2018 - 2022	324.2 ±2.4	238.0	86	492	282
SATU	EHZ, EHN, EHE	B	6.6537	100.0833	2018 - 2022	209.0 ±2.3	48.5	161	452	272
SAWA	HHZ, HHN, HHE	A	15.6716	100.1321	2018 - 2022	39.1 ±2.7	93.0	54	402	300
SRKA	HHZ, HHN, HHE	A	9.1450	99.6334	2018 - 2022	18.0 ±2.7	338.7	39	337	205
TMDB	BHZ, BHN, BHE	C	13.6684	100.6068	2009 - 2018	200.9 ±8.8	0	159	704	105
	HHZ, HHN, HHE	A			2021 - 2022	353.5 ±6.2	0	7	120	47
UTHS	EHZ, EHN, EHE	B	15.3535	100.0095	2018 - 2021	107.0 ±1.7	276.4	169	474	231

*A = Guralp CMG-3TB (120 sec. Broadband) + Guralp Affinity

*B = Guralp CMG-3TB (1 sec. Short-period) + Guralp Affinity

*C = Geotech KS-2000BH (Broadband) + Geotech Smart-24R

* Difference (°) column represent the degrees of difference between the orientation result and the TMD metadata calculated by $\min(|A-B|, 360-|A-B|)$, where A and B are the orientation result and the TMD metadata respectively.

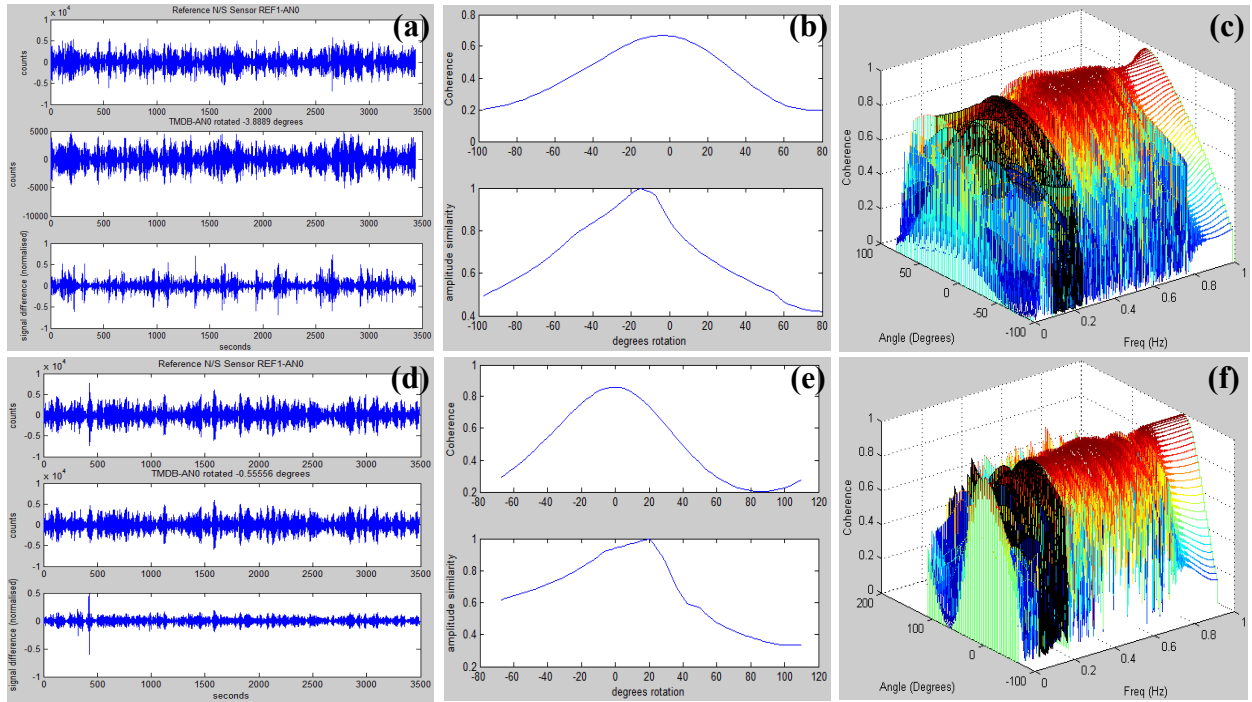


Fig. S1 Signal correlation between the surface reference (Guralp CMG-3T 120sec) and down-hole sensor (Guralp CMG-3TB 120sec) which has the same instrument response and orientation results. (a and d) Time series of reference sensor (N/S component) and a borehole sensor (TMDB-AN0) in perfect N/S orientation and signal difference plot for day and night times respectively. (b and e) The peak of the coherence curve therefore corresponds to the angle of rotation which best matched the reference sensor (upper graph) and the overall amplitude similarity of the borehole rotated signal (lower graph) for day and night times respectively. (c and f) A plot of coherence, frequency and rotation angle for day and night times respectively, the black line curve show the frequency use in correlation calculation.

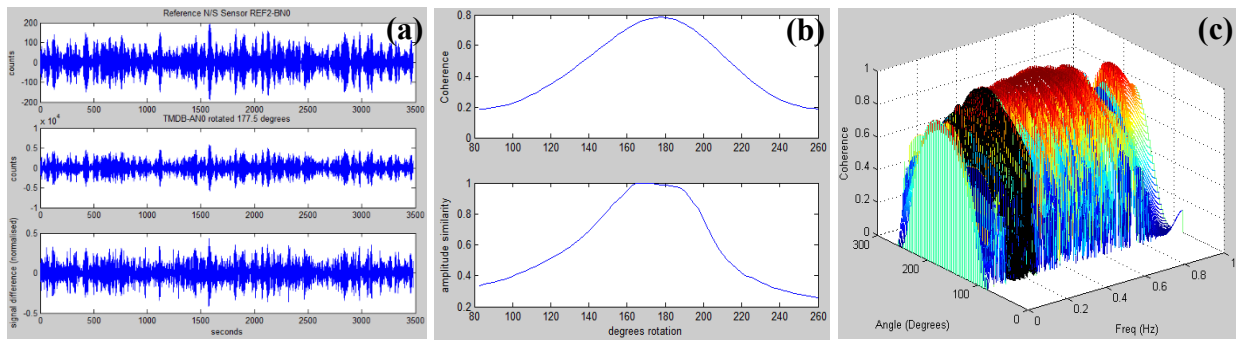


Fig. S2 Signal correlation between the surface reference (Guralp CMG-3ESPC 1sec) and down-hole sensor (Guralp CMG-3TB 120sec) (a) show the down-hole test sensor aligned at $\sim 178^\circ$ or polarity reversal (b) caused by the difference instrument response of the surface reference sensor ($\sim 180^\circ$ phase shift).