

Pattern-search inversion for hypocenter location

Lilly Han, Joe Wong, and John C. Bancroft

ABSTRACT

Pattern-search (PS) inversion on one-component (1C) recordings was used to locate hypocenters, in contrast to our back-propagation analysis method for three-component (3C) microseismograms. The efficiency and associated accuracy of PS inversion was examined through its regression progress in four scenarios.

METHOD

The PS algorithm (Hookie and Jeeves, 1960) was first introduced as an unconstrained search technique that does not require derivatives. Compared to gradient-based methods, the PS algorithm is often faster and much less prone to being trapped in local minima.

EXPERIMENTS

1. Velocity calibration by PS inversion

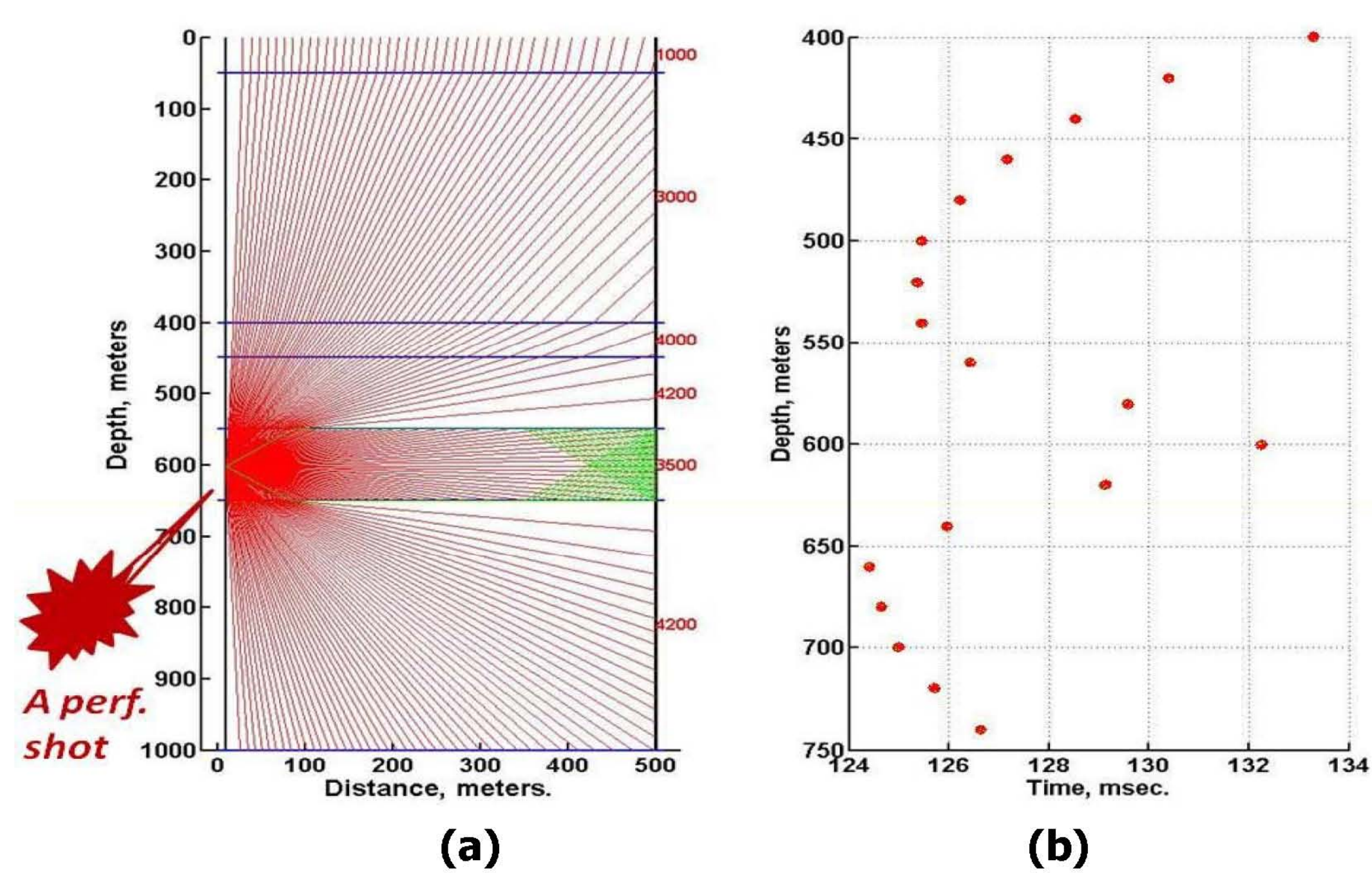


FIG.1. (a) Ray-tracing (red raypaths) from a perforation shot (red explosion) to an observation well through a six-layered horizontal velocity model, and (b) The associated first P-arrival times.

Table 1. PS regression progress to calibrate the velocity model

Iterations	Evaluations	V_1 (m/s)	V_2 (m/s)	V_3 (m/s)	V_4 (m/s)	V_5 (m/s)	V_6 (m/s)	RMS error (ms.)
0	0	1000	2000	2000	2000	2000	2000	16.5
10	8	1012.6	4030.9	2107.1	3040.2	4509.3	2129.9	5.14
20	58	1109.8	5010.7	3059.9	4103.2	4089.2	4035.6	1.66
40	229	1050.6	2510.9	4250.3	4125.7	3509.9	4125.1	0.45
True	Model :	1000 m/s	3000 m/s	4000 m/s	4200 m/s	3500 m/s	4200 m/s	

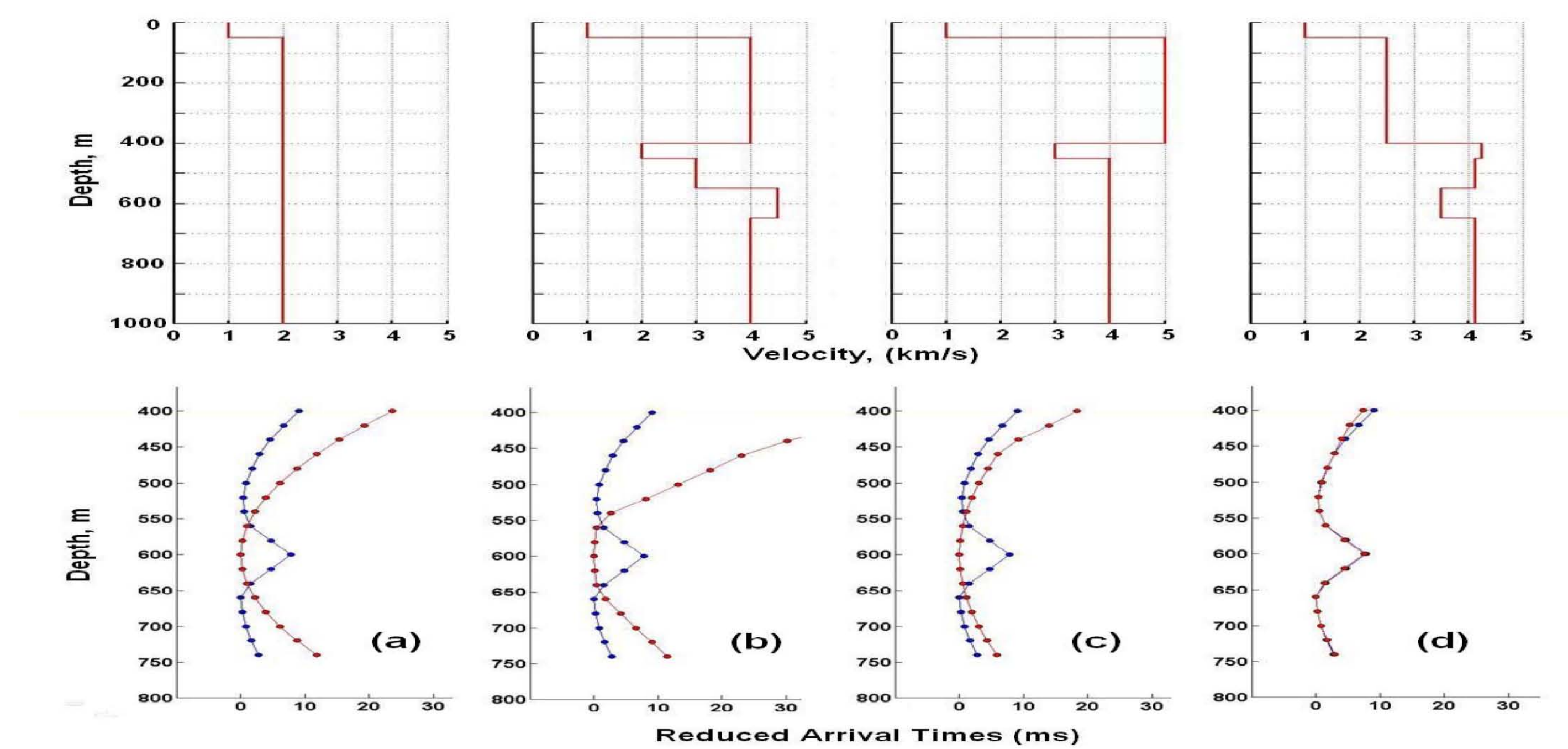


FIG.2. The velocity profiles (top panel) and the arrival-time misfits (bottom panel) between observed (red dots) and calculated (blue dots) times resulted from (a) the initial guess, (b) 10 iterations, (c) 20 iterations, and (d) 40 iterations, by the PS inversion.

2. Hypocenter location by PS inversion

Table 2: PS regression progress to locate a hypocenter from a single vertical well.

Iterations	Evaluations	X_s (m)	Y_s (m)	Z_s (m)	RMS error (ms)
0	0	100	0	800	8.09
20	56	40.7	0	614.4	0.64
40	115	19.3	0	623.0	0.30
60	186	9.9	0	619.8	0.02
True	Location :	10 m	0 m	620 m	

Table 3: PS regression progress to locate a hypocenter from three shallow vertical wells.

Iterations	Evaluations	X_s (m)	Y_s (m)	Z_s (m)	RMS error (ms)
0	0	100	100	800	20.12
11	12	50.1	12.9	600.5	6.38
21	30	26.7	6.1	603.9	0.30
31	91	10.8	2.3	607.5	0.15
True	Location :	10 m	0 m	620 m	

Table 4: PS regression progress to locate a hypocenter location from surface geophone arrays.

Iterations	Evaluations	X_s (m)	Y_s (m)	Z_s (m)	RMS error (ms)
0	0	100	0	800	8.09
20	56	40.7	0	614.4	0.64
40	115	19.3	0	623.0	0.30
60	186	9.9	0	620.0	0.02
True	Location :	10 m	0 m	620 m	

CONCLUSION

The searching efficiency of PS method is highest for the case of three wells (Table 3), least for the case of surface geophones (Table 4). The efficiency for the case of a single well lies between the other two.

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