IOSR Journal of Applied Geology and Geophysics (IOSR-JAGG)
e-ISSN: 2321–0990, p-ISSN: 2321–0982.Volume 1, Issue 3 (Sep. – Oct. 2013), PP 66-81
www.iosrjournals.org

Relocation of Earthquakes that Occurred Beneath Parkfield Region of California using VELHYPO

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Abstract: *When only direct-waves are inadequate, different combinations of both direct- and refracted-waves are used to determine hypocentral parameters of local earthquakes. Compared with only direct-waves, the addition of refracted-waves tends to increase errors of hypocentral parameters. This is true especially when the velocity structure of the region under investigation is not known. We use an accurate and fast algorithm to determine the hypocentral parameters based on an optimum 1-D velocity model yielding a minimum misfit error in media with multiple refracted-waves as first arrivals. Using the algorithm, we relocated earthquakes that occurred beneath the Parkfield region of California during the period between January 2000 and December 2000. The shallow part of the velocity model used in the study area has high velocity contrast among layers. Therefore, refracted-waves are recorded as first-arrival phases at most stations around the region for events of shallow focal depths (less than 3km). The study area covers the transition between the creeping segment of San Andreas Fault (SAF) to the northwest and the locked segment to the southeast. Accuracy test for the algorithm was conducted using some reference models. We compare the inverted hypocentral parameters with those determined by previous studies using HYPOINVERSE and the HypoDD. The epicentral distributions of the three methods show a close relationship with the regional fault distribution. However, compared to HypoDD, the epicentral distribution of HYPOINVERSE shifted slightly along the fault lines while the epicentral distribution of VELHYPO moved further in the same direction. The result of VELHYPO suggests that the dip of San Andreas Fault is 6-10^{o}SW while the results of HPOINVERSE and HypoDD suggest that the dip of San Andreas Fault is nearly vertical and/or 3-7^{o}NE. This study supports the result of previous studies that San Andreas Fault is non-vertical but dips to southwest as part of a possible propeller-shape.*
Keywords: *Direct waves and Refracted-waves, Algorithm, Parkfield, Relocate Earthquakes, San Andreas Fault, SW dip, support propeller-shape.*

1. Introduction

Reliable determination of the hypocentral parameters (latitude, longitude focal depth and origin time) has been one of the basic tools in earthquake seismology. It provides initial insight into observed seismicity and faults or subsurface structures responsible for the observations. Unfortunately, the precision of locations is affected by limitations imposed by factors, which among others include; data quality (i.e., accuracy of the arrival times, the discernible seismic phases, signal-noise- ratio, etc.), station distribution, prior information of the velocity structure of the area, and most importantly, the algorithm used for locating the earthquakes. Even with dense and well distributed station coverage as well as excellent quality data, techniques (algorithm) to determine hypocentral parameters still fall short of very accurate results because precise velocity structure of the region under investigation is not well known. There are usually tradeoffs between earthquake locations and velocity structure. Although the earth's velocity structure may have both vertical and lateral variations, in many cases a simplified 1-D velocity model can produce results that are consistent with observed data. Hence the need to develop an approximate 1-D velocity model for hypocenter inversions.

The Parkfield section of San Andreas Fault (SAF) is bounded on the northwest by a 150-km-long creeping section, where numerous small earthquakes occur, and on the southeast by hundreds of kilometers of locked fault that last broke in the great 1857 M_w=7.9 Fort Tejon earthquake (*Sieh*, 1978). The study area is bordered by latitude 35^{o}40′N - 36^{o}20′N and longitude 120^{o}12′W -120^{o}54′W (about 80 square kilometers). The U.S. Geological Survey (USGS) 1-D velocity model beneath Parkfield area suggests that refracted-waves from multiple boundaries dominate as first-arrivals to most recording stations in the region due to large velocity contrasts among the first few layers. This is true especially for shallow focal depth events. Unfortunately, refracted-waves show more sensitivity to difference in velocity structure between the true and used models. Therefore, refracted-waves have high possibility to increase errors in determination of hypocentral parameters.

In this study, we introduce an accurate and fast scheme to determine the hypocentral parameters based on an optimum 1-D velocity model yielding a minimum misfit error in media with multiple refracted-waves as first arrivals. To get an optimum velocity model, the algorithm searches iteratively by shifting an initial reference model within a prescribed range. We test the accuracy of hypocentral parameters using synthetic data. We then apply the algorithm to relocate earthquakes that occurred around Parkfield, California during the period from January 2000 to December 2000. We finally compare the result of this study with those obtained by HYPOINVERSE and HypoDD.

II. Literature Review

i. Geology and Tectonic setting of the Study Area

The Parkfield section of the San Andreas Fault (SAF) spans the transition between the creeping segment of the fault to the northwest and the locked segment to the southeast, which last broke in the great 1857 Fort Tejon earthquake (Sieh 1978). It is reported that the geology of the area is dominated by the SAF system and has three other faults which are believed to play varying roles in the local geology (Sims, 1990; Sims and Hamilton, 1990). The faults include; the Gold Hill Fault immediately northeast of the SAF mapped as a southwest dipping thrust (Sims, 1990; Sims and Hamilton, 1990), the Southwest Fractured Zone immediately southwest of the SAF (Brown, et al., 1967), and the White Canyon Fault in the Cholame Valley several kilometers further to the south of SAF (Sims and Hamilton, 1990). The area is of interest because of the very different basement rocks juxtaposed by the fault. The rock types in this section are generally characterized by faster materials (Salinian granitic rocks) covered by a maximum of 2 km of Tertiary and Quaternary marine and non-marine sediments and volcanics on the southwest side of the fault, and slower material (Franciscan rocks and Great Valley sequence) on the northeast side (Walter & Mooney 1982; Lees & Malin 1990). At least seven earthquakes of ~M6 occurred on the Parkfield segment since 1857, with the most recent on 2004 September 28 (Bakun *et al.* 2005). The quasi-periodicity of the previous six events led to the deployment of many seismic and other instruments as part of the Parkfield Earthquake Prediction Experiment (Bakun & Lindh 1985). Velocity models there show high v_p/v_s ratio along the fault near the surface and at depth within the fault zone, and a pronounced strong vertical velocity gradient in the upper 2 km of the section (Michelini and McEvilly, 1991; Eberhart-Phillips and Michael, 1993). A total of 97 stations recorded at least one data. The station distribution is shown in figure 1 and the list of stations and their corrections is shown in Appendix I.

ii. Existing Techniques

Some conventional techniques for determining hypocentral parameters include HYPO-71 (Lee and Lahr, 1975), HYPOINVERSE (Klein, 1978), HYPOELLIPSE (Lahr, 1980), VELEST (Kissling et al., 1994), HYPOSAT (Schweitzer, 2001). Hypocentral inversion methods are performed to minimize residuals between calculated and observed traveltimes. The conventional methods calculate traveltimes based on fixed velocity models. However, these conventional methods which are based on fixed velocity models can yield correct hypocentral parameters only if true velocity structure is implemented. The inverted hypocentral parameters can vary by the implemented velocity model (Lomnitz, 2006). The consequence of such approach yields errors to determined hypocentral parameters. To avoid errors due to the implementation of incorrect velocity models, hypocentral inversion methods have been developed to determine both the hypocentral parameters and velocity structures simultaneously (e.g., Pavlis and Booker, 1983; Thurber, 1985, 1992; Kissling et al., 1994), which were found to be useful for analysis of multiple events. In these methods, seismic velocities of each layer are considered to be additional unknown parameters. However, such methods are not only expensive in computation, but may also yield hypocentral parameters and velocity structures that tend to vary with the initial velocity models implemented. Thus, it may be required to implement initial velocity models that are close to the actual velocity structures for determination of accurate parameters. However, the implementation of velocity models close to the actual velocity structures is somewhat difficult because 1-D and 2-D velocity models inherently have limitations in representation of the actual 3-D Earth structures.

Recently, a double-difference method based on differential traveltimes (hypoDD) was proposed. The method was found to be useful for analysis of clustered events (Waldhauser and Ellsworth, 2000). The method determines the relative locations of the clustered events from traveltime differences among pairs of waveforms that are estimated precisely with the help of waveform cross-correlation. However, the hypoDD is supposed to implement initial hypocentral parameters that are calculated by usual conventional methods that yield the hypocentral parameters depending on the reference velocity models implemented. Thus, the hypocentral parameters from hypoDD are inherently dependent on the reference velocity models. Also, the hypoDD can be applicable only to clustered events.

Therefore, it is required to determine hypocentral parameters accurately with little dependence on a given or initial velocity model. Such methods may be particularly useful for regions of which velocity structures are poorly known. Kim et al. (2006) proposed a full inversion method based on a genetic algorithm, GA-MHYPO, which determine both a best-fitting velocity model and hypocentral parameters. Here, the best-fitting model is not the actual velocity structure, but an optimum velocity model yielding the minimum traveltime residual. It was found that the GA-MHYPO yields hypocentral parameters with higher accuracy than conventional methods, and is rarely dependent on the initial velocity model (Hahm et al., 2007). However, GA-MHYPO suffers from high computational costs due to iterative velocity refinement based on the genetic algorithm, which hinders prompt analysis in practical application.

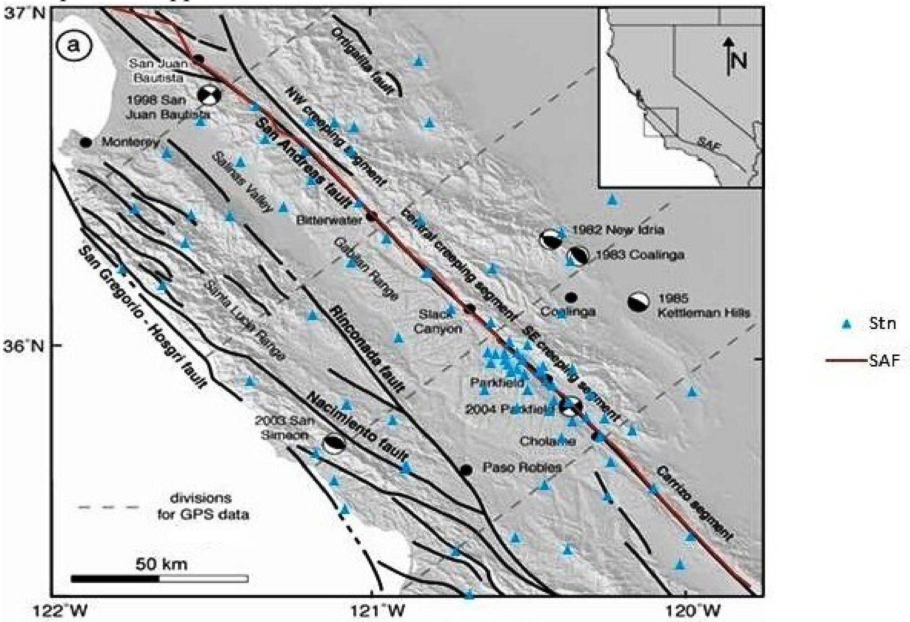

Figure 1 Distribution of 97 stations and the San Andreas Fault line around Parkfield region, California. Map is courtesy Titus et al, 2010.

III. Model Refinement and Velocity Model

i. Model Refinement

We use an algorithm to search an optimum 1-D velocity model yielding minimum misfit errors for hypocentral inversions. The algorithm is based on a weighted average P-wave velocity in a medium between source and receiver. The algorithm iteratively selects the best-fitting average velocity from the results of grid searching methods within a prescribed range. We search an optimum velocity model by modifying the velocities in each layer of given velocity model that has a constant number of layers and constant thicknesses of layers. An optimum velocity model is determined with an idea that a velocity model with a proper average velocity and velocity gradient reproduce synthetic traveltimes that are close to the observed traveltimes with sufficient level of accuracy. Here, the implemented average velocity may be close to that of actual structure. First, we determine a semi-optimum 1-D *P* and *S* velocity model. We prepare a set of *P* velocity models that are shifted with a constant interval from the given *P* velocity model:

$$\alpha_i^n = \alpha_i^0 + n\Delta\alpha \quad (1)$$

where $\Delta\alpha$ is a constant velocity interval, n is an integer, α_i^0 is the initial *P* velocity for the i^{th} layer, and α_i^n is the n times shifted *P* velocity for the i^{th} layer. Here, the *S* velocity models can be prepared subsequently from the *P* velocity model and a given v_p / v_s ratio. We can vary v_p / v_s ratio within a fixed window typical of the v_p / v_s ratio in the crust. In this study, we scale the *P* arrival times by a factor of 1/√3 due to insufficient *S* arrival times in many of the events.

The optimum *P* velocity model is determined by iterative refinement of velocity model with consecutive implementation of smaller $\Delta\alpha$ in equation (1). We prepare a set of $\Delta\alpha$ that is composed of 0.1, 0.01, 0.001, and 0.0001 km/s. In every refinement of velocity, we improve the accuracy of the velocities to higher places of decimals. For instance, when we refine the velocity model with $\Delta\alpha$ of 0.01 km/s, we improve the accuracy of the velocities to 2 places of decimals. In this case, the optimum velocity model to 1 place of decimals is used as the reference velocity model in determining an optimum velocity model to 2 places of decimals. The optimum velocities to 2 places of decimals are searched in ranges between -0.05 to 0.04 km/s with respect to the optimum velocities to 1 place of decimals. Such consecutive refinement of velocity models with application of smaller $\Delta\alpha$ allows us to reduce computational time effectively. Figure 2 presents an example of the model refinement scheme for a velocity model with a weighted average velocity that is larger by 0.1785 km/s than the reference velocity model applied. In the first round of model refinement, the search to 1 place of decimals is between -0.6 and 0.6 km/s with respect to the reference velocity at $\Delta\alpha$ of 0.1 km/s. The second round is to 2 places decimals varying between -0.05 and 0.04 km/s with $\Delta\alpha$ of 0.01 km/s. The optimum velocity to 3 places of decimals is found at a velocity difference of 0.179 km/s in the third round.

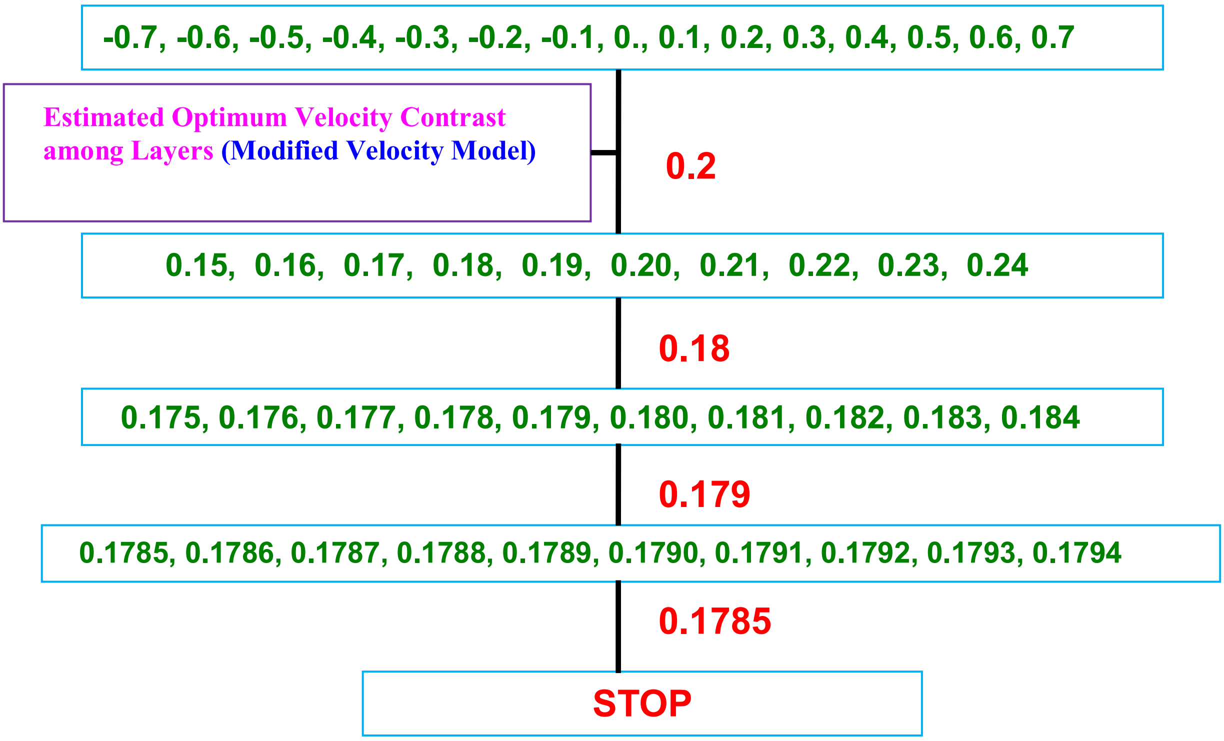

Figure 2 Example of the model refinement scheme for a velocity model with a weighted average velocity that is larger by 0.1785 km/s than the reference velocity model applied.

ii. Velocity Model

Researches in the past have led to the establishment of different velocity models across Northern California. The U.S. Geological Survey (USGS) P-wave velocity model for Parkfield region is used as the true velocity model to generate synthetic data. The model is composed of nine layers with irregular intervals between boundaries consisting of a 0.25km-thick top layer with a relatively low P- and S-wave velocity and a high velocity contrast across the second and the third boundaries (Figure 3; Table 1). We apply the algorithm to test the accuracy of inverted hypocentral parameters. We also check the dependency of inverted hypocentral parameters on the implemented velocity models. Validation tests are conducted with synthetic data. Using the U. S. Geological Survey model, we compute cross-over distances at some selected depths for coincident epicenter. It is observed that almost all first arrivals for the first few layers are “refracted-waves”. It generally appears that, for focal depths less than 4km, first arrivals appear to be refraction from either the bottom of the source layer or from the bottom of the first and even second layers beneath the source layer. The model suggest that only at epicentral distances greater than 85km that waves refracted off the 25km-Moho surface become first arrivals for focal depths of less than 2.5km. We observe that only at focal depths greater than 6km that many stations of epicentral distances less than 80km record direct-wave as first arrivals.

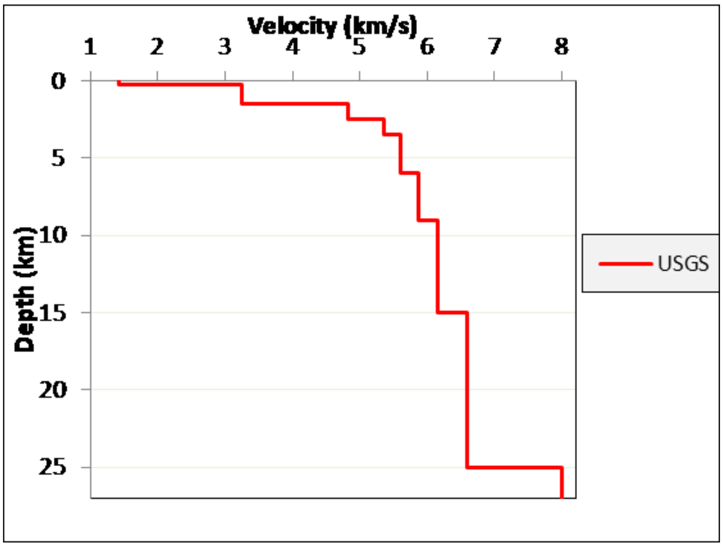

Figure 3 U.S. Geological Survey 1-D velocity model beneath Parkfield

	Depth (Km)	Velocity (Km/s)
1	0.00	1.42
2	0.25	3.24
3	1.50	4.82
4	2.50	5.36
5	3.50	5.60
6	6.00	5.87
7	9.00	6.15
8	15.00	6.60
9	25.00	8.00

Table 1 USGS 1-D velocities and boundary depths beneath Parkfield

IV. Computational Result

Conventional methods can be classified into two groups on the basis whether the velocity models are refined or not. One group of methods including HYPO-71 (Lee and Lahr, 1975), HYPOINVERSE (Klein, 1978) and HYPOELLIPSE (Lahr, 1980) determines the hypocentral parameters based on given velocity models. The other group of methods including VELEST (Kissling et al., 1994) determines hypocentral parameters along with refinement of velocity models. We implement a hypocentral inversion method based on a two-point ray tracing MHYPO (Hahm et al., 2007) of which inversion algorithm is modified from HYPO-71. The best-fitting velocities are searched using a fitness function that assesses the differences between observed and theoretical traveltimes of *P* and *S* waves. The determined velocities of layers may not match with the true velocities, but the estimated weighted average velocity between a source and stations should be close to the true weighted average velocity.

The accuracy of the algorithm was tested using synthetic data. The hypocentral parameters are determined more accurately using only direct waves if available number of direct waves is sufficient than using combination of direct and refracted waves. Generally, errors of hypocentral parameters are reduced when low grade (D) weighting factor is assigned to refracted-waves instead of high grade (A). This is because travel-time of refracted-wave is more sensitive than that of direct wave for velocity structure difference between true and model. Therefore, in VELHYPO computations, assigning low grade weighting factor to refracted-waves, reduces errors in inversion of hypocentral parameters when refracted-waves are combined with direct-waves as first-arrival data set.

We invert for hypocentral parameters of 333 earthquakes that occurred between January 2000 and December 2000. The data was from the Northern California Seismic Network (NCSN) catalog. A total of 97 stations recorded at least one data. Station corrections were determined by taking the average time residual for each station. This was achieved first by relocating about 300 events without station correction and taking the average residual of each station. The stations are represented by blue triangles in figure 4. We classify the focal depths into four ranges (less than or equal to 3.5km, 3.51-6km, 6.01-9km and greater than 9km focal depths). Different colors are used to represent the various ranges of focal depths. Compared to the USGS model, the weighted average velocity between hypocenters and stations around the study region range between -23.9 and +45.1% and increased by 16.2% on average. The weighted average velocities of 58 events are less than the USGS model while the weighted average velocities of the rest events are more than the average velocity of the USGS model. These large velocity variations may be caused by lateral (horizontal) velocity variations and 1-D velocity structure difference between the true velocity structure and the used model, especially the differences of layer number and depth boundaries among layers.

The inverted hypocentral parameters obtained in this study are compared with those determined by previous studies using HYPOINVERSE and the HypoDD. Numerical values of the results are shown in Appendix II. The relocated epicenter distribution shows a close relationship with the regional fault distribution. Figures 5a, 5b and 5c show epicentral distribution calculated by VELHYPO, HYPOINVERSE and hypoDD respectively. The perpendicular distances of the epicenters from the fault line are more disperse for VELHYPO (Fig. 5a) than HYPOINVERSE (Fig. 5b) which in turn are more disperse than HypoDD (Fig. 5c). The epicentral distribution of VELHYPO shifted slightly south-westwards when compared with HYPOINVERSE and the

HypoDD. This favors a southwest steep dipping fault beneath the study area. On the other hand, the more linear epicentral distribution of HypoDD favors a vertical strike fault beneath the study area.

Figures 6a, 6b and 6c show focal depth distribution with respect to latitude calculated by VELHYPO, HYPOINVERSE and hypoDD respectively. In this study, the focal depths of 92 events have less than or equal to 3.5km compared with 34 events for HYPOINVERSE and 54 events for the HypoDD. 136 events between 3.51 and 6km focal depths compared with compared with 158 events for HYPOINVERSE and 159 events for the HypoDD. 86 events between 6.01 and 9km focal depths compared with 91 events for HYPOINVERSE and 68 events for the HypoDD. The focal depths of 19 events are greater than 9km compared with 50 events for HYPOINVERSE and 52 events for the HypoDD. VELHYPO focal depths range between 0.14 and 13.7km, HYPOINVERSE between 0.03 and 19.19km while HypoDD range between 0.11 and 16.82km. Most VELHYPO events of which focal depths are greater than 9km occur south of latitude 36^{o}N which constitute part of the locked section of the fault.

We divide the study area into two regions along latitude 36.08^o. Figures 7(a-f), show cross-section of focal depths along the perpendicular to the SAF North and South of latitude 36.08^o from the fault line calculated by VELHYPO, HYPOINVERSE and HypoDD. In the North of latitude 36.08^o, events are more sparsely distributed for VELHYPO (Fig .7a) than HYPOINVERSE (Fig. 7b) which in turn are more sparsely distributed than HypoDD (Fig.7c). However, in the South of latitude 36.08^o, events are less sparse for VELHYPO (Fig. 7d) and HYPOINVERSE (Fig.4.9e) than HypoDD (Fig. 7f). VELHYPO results show a trend where normal distances from fault line generally increase with focal depth (Fig. 7a and 7d). The trend suggests a 6-10^{o}SW dip of SAF beneath the region. On the other hand, both HYPOINVERSE (Figures 7b and 7e) and HypoDD (Figures 7c and 7f) show linearly vertical and/or a dip of 3-8^o NE of SAF. The HypoDD trend is steeper than HYPOINVERSE. The result of this study support the previous studies that propose the type of SAF in studied region is a propeller type whose dipping direction is southwest (Fuis et. al., 2012).

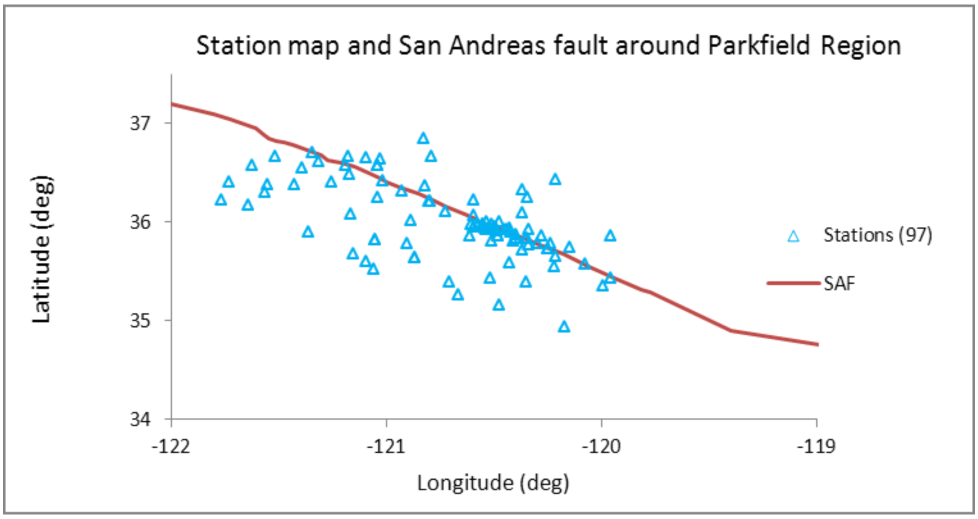

Figure 4 Station map and San Andreas Fault around Parkfield region

V. Conclusion

We employed VELHYPO to determine hypocentral parameters of 333 earthquakes that occurred beneath the Parkfield during the period between January and December of the year 2000. The study area covers the transition between the creeping segment of San Andreas Fault (SAF) to the northwest and the locked segment to the southeast. Hypocentral parameters inversion of the earthquakes that occurred in Parkfield region of San Andreas Fault are confined to the top 14km with the bulk of the events occurring around the top 6km. Most events of which focal depths are greater than 9km occurred below latitude 36^{o}N. Epicentral distribution obtained from VELHYPO shift slightly southwest when compared with the results of previous studies using HYPOINVERSE and the HypoDD. Although the events are more scattered north of latitude 36.08^o, the result of this study shows a trend where normal distance from fault line generally increase with focal depth. The result of VELHYPO suggests that the dip of San Andreas Fault is 7-15^{o}SW while those of HPOINVERSE and HypoDD suggest that the dip of San Andreas Fault is nearly vertical and/or 3-7^{o}NE beneath the region. This study supports the result of previous studies that San Andreas Fault is non-vertical but dips southwest as a part of propeller-shape.

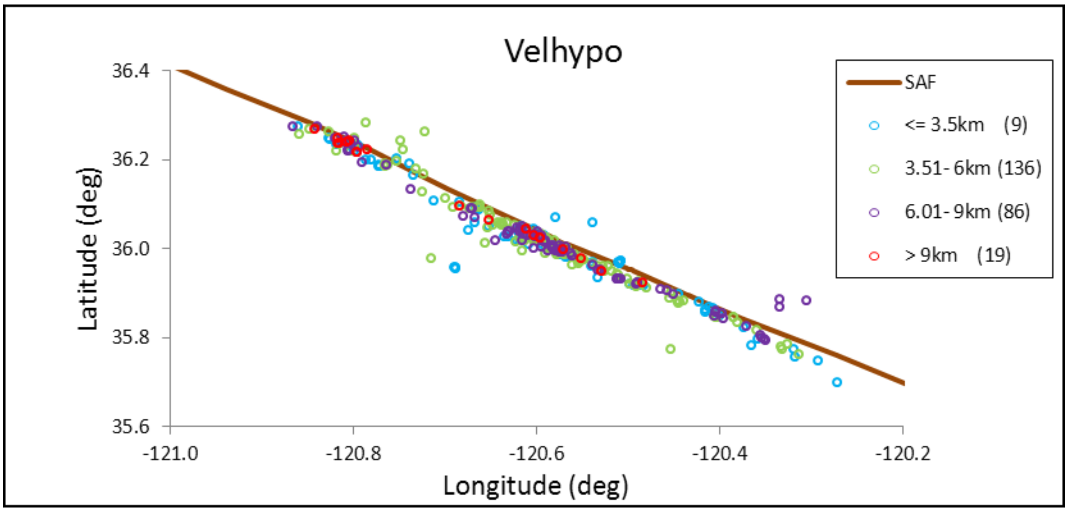

Figure 5(a) VELHYPO epicentral and depth distribution

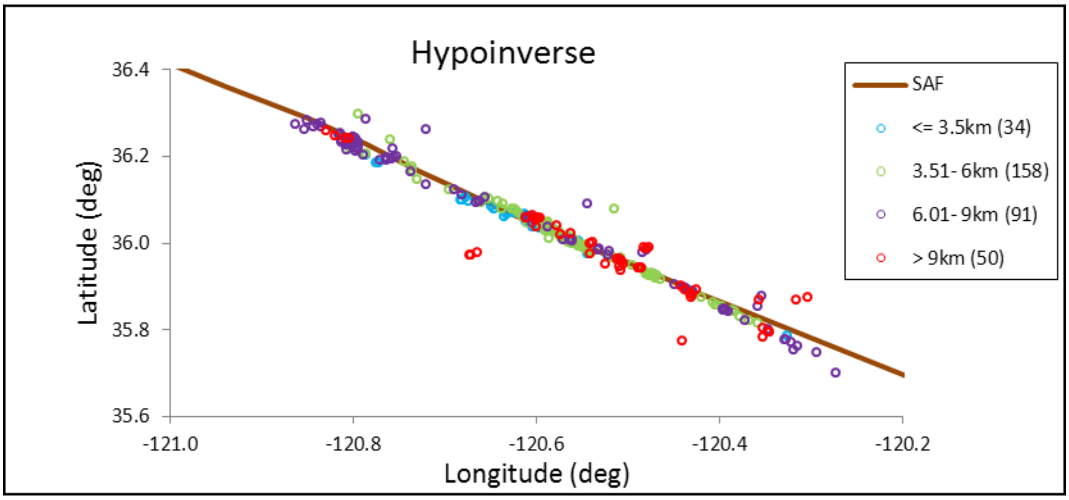

Figure 5(b) HYPOINVERSE epicentral and depth distribution

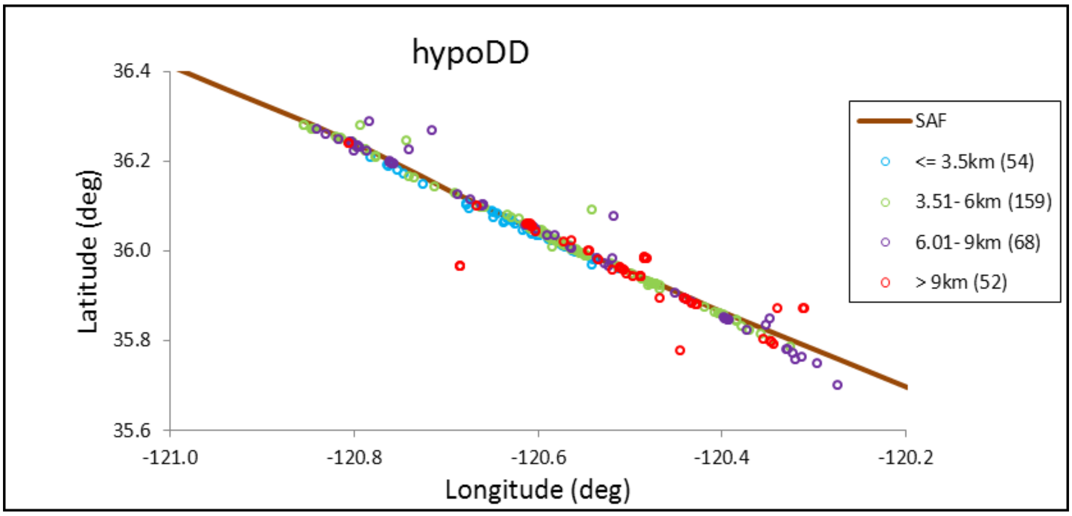

Figure 5(c) HypoDD epicentral and depth distribution

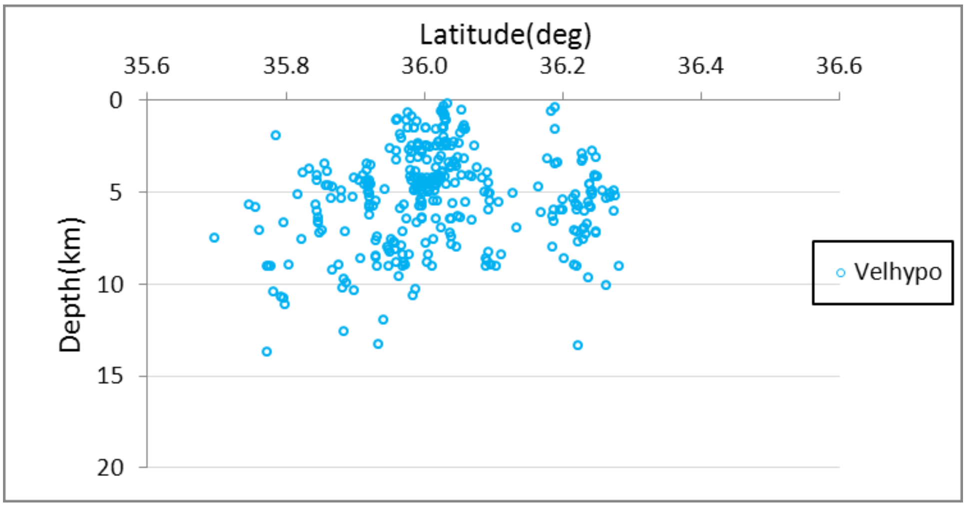

Figure 6(a) VELHYPO latitude and depth distribution

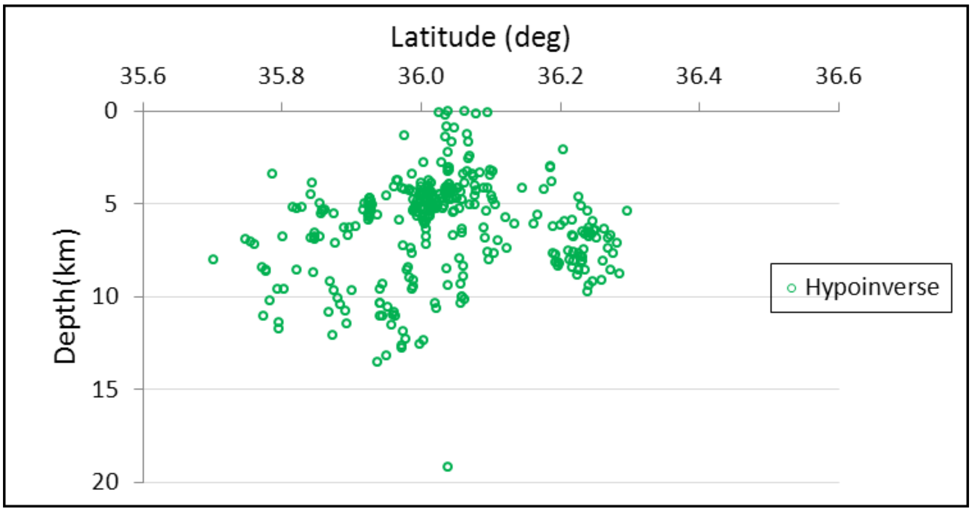

Figure 6(b) HYPOINVERSE latitude and depth distribution

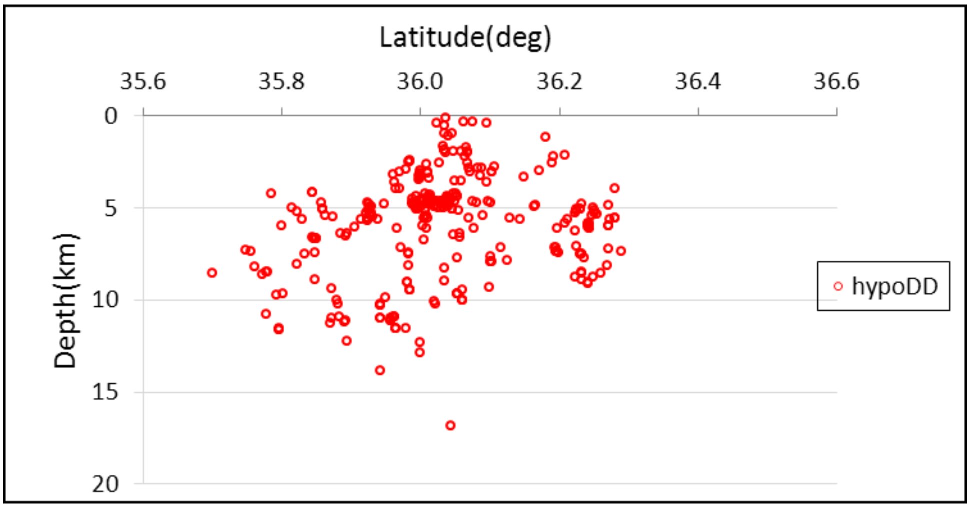

Figure 6(c) HypoDD latitude and depth distribution

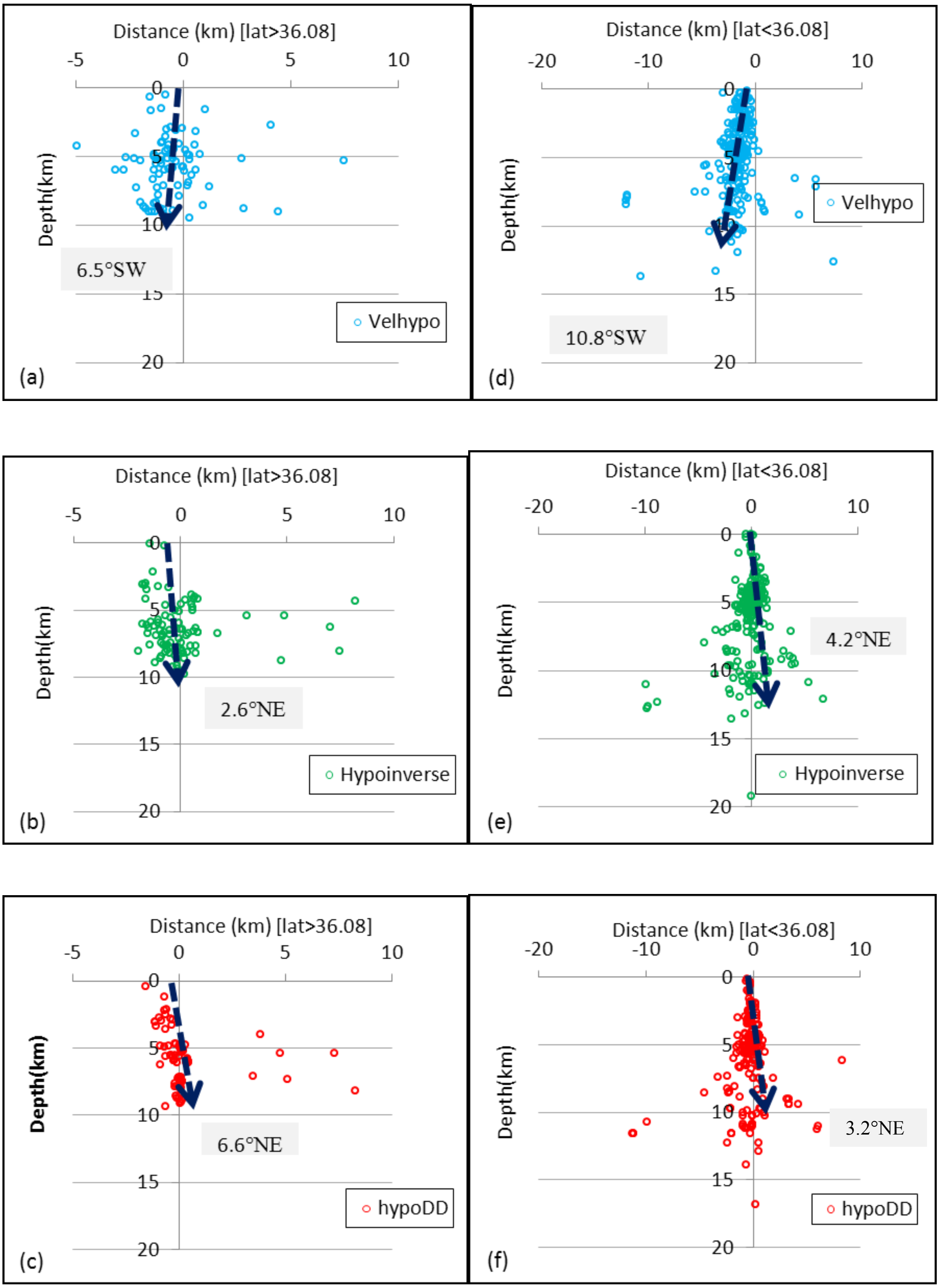

Figure 7 Focal depth distances from SAF showing dipping angles of SAF at latitude > 36.08° and latitude < 36.08° for Velhypo (a) & (d), Hypoinverse (b) & (e) and hypoDD (c) & (f).

Acknowledgements:

This work was funded by the Korean Meteorological Administration Research and Development Program under Grant CATER 2012-8130.

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Appendix I: List of used stations and their corresponding calculated average delay.

No.	Station	Latitude (deg)	Longitude (deg)	Elev (km)	Delay (sec)
1	BAP	36.1804	-121.6444	1.193	0.0040
2	BAV	36.6460	-121.0302	0.572	0.2700
3	BBG	36.5780	-121.0392	1.065	0.2214
4	BBGB	36.5785	-121.0396	1.089	0.0680
5	BCG	36.7096	-121.3428	0.250	-0.1060
6	BCW	36.3065	-121.5669	1.505	-0.1783
7	BEH	36.6648	-121.1754	0.334	0.6750
8	BEM	36.6611	-121.0968	0.464	-0.3880
9	BJC	36.5472	-121.3939	0.173	-0.0567
10	BJO	36.6110	-121.3142	1.021	-0.4455
11	BMS	36.6631	-120.7929	0.780	0.5230
12	BPC	36.5734	-121.6269	0.173	0.2995
13	BPI	36.4901	-121.1696	0.301	-0.1563
14	BPO	36.2284	-121.7677	0.330	-0.2450
15	BPR	36.4071	-121.7306	0.711	0.0261
16	BRM	36.8451	-120.8247	0.343	-0.2390
17	BRV	36.4247	-121.0191	0.525	0.1380
18	BSG	36.4138	-121.2552	0.161	-0.1863
19	BSM	36.3837	-121.4292	0.884	-0.1465
20	BSR	36.6674	-121.5203	0.375	0.0025
21	BVL	36.5749	-121.1901	0.479	-0.0560
22	CCRB	35.9572	-120.5516	0.595	-0.0393
23	CS	35.6005	-121.0940	0.030	0.1480
24	EADB	35.8952	-120.4226	0.469	-0.0103
25	FROB	35.9110	-120.4869	0.515	-0.1444
26	GHIB	35.8322	-120.3473	0.393	-0.0698
27	HAST	36.3887	-121.5514	0.542	-0.0450
28	JCNB	35.9390	-120.4311	0.533	0.0798
29	JCSB	35.9212	-120.4340	0.454	0.1352
30	LCCB	35.9800	-120.5142	0.385	0.1342
31	MMNB	35.9565	-120.4960	0.701	0.0615
32	PAD	35.6400	-120.8662	0.430	0.0172
33	PAG	35.7325	-120.2504	0.436	-0.0310
34	PAGB	35.7307	-120.2499	0.480	-0.0410
35	PAN	35.7801	-120.9071	0.426	0.0751
36	PAP	35.8958	-121.3655	1.044	-0.1866
37	PAR	36.2493	-120.3428	0.452	0.1360
38	PBI	35.1614	-120.4750	0.522	0.1220
39	PBM	35.3945	-120.3539	1.049	-0.2670
40	PBP	35.5791	-120.0775	0.569	0.2178
41	PBS	35.7457	-120.1490	0.811	-0.0855
42	PBW	36.3167	-120.9309	0.302	0.0153
43	PCA	35.9315	-120.3382	1.163	0.0548
44	PCB	35.5184	-121.0607	0.164	0.0923
45	PCC	36.0898	-121.1636	0.372	0.1249
46	PCM	35.8055	-120.4096	0.671	0.0242
47	PDR	36.3358	-120.3700	0.428	0.0230
48	PFR	35.9107	-120.4874	0.534	-0.1432
49	PGH	35.8308	-120.3538	0.405	-0.0923
50	PHA	35.8362	-120.3986	0.398	0.0216
51	PHC	35.6822	-121.1537	0.502	0.0278
52	PHF	35.8816	-120.4016	0.457	0.0168
53	PHO	35.8667	-120.4797	0.753	-0.0273
54	PHOB	35.8666	-120.4796	0.796	-0.0351
55	PHP	35.9805	-120.6068	0.548	-0.0165
56	PHR	36.3730	-120.8189	0.707	-0.0080
57	PHS	35.8238	-121.0538	0.451	0.0699
58	PHSB	35.8240	-121.0539	0.475	-0.0171
59	PIR	35.5544	-120.2233	0.471	0.0905
60	PJC	36.0959	-120.3716	0.403	0.2478
61	PJU	36.2270	-120.5935	0.925	0.0752
62	PKD	35.9452	-120.5416	0.583	-0.0440
63	PKL	35.7730	-120.3399	0.422	0.0289
64	PKY	35.2640	-120.6667	0.101	0.1530
65	PL11	35.9740	-120.5512	0.627	0.1630
66	PL11B	35.9745	-120.5516	0.659	0.0091
67	PLO	36.2463	-121.0430	0.251	-0.1178
68	PMC	35.7252	-120.3706	0.471	0.0877
69	PMG	35.4298	-120.5201	0.486	-0.2305
70	PMM	35.9563	-120.4985	0.751	0.1150
71	PMP	36.2157	-120.7974	0.754	-0.0864
72	PMPB	36.2159	-120.8013	0.802	-0.0197
73	PMR	35.7843	-120.2368	0.498	-0.0716
74	PPC	35.9497	-120.5954	0.558	-0.0922
75	PPG	35.8626	-119.9565	0.177	0.4170
76	PPO	35.8667	-120.6160	0.446	0.3045
77	PPT	36.1091	-120.7242	0.481	0.0148
78	PSA	36.0247	-120.8892	0.150	0.0526
79	PSC	35.5884	-120.4279	0.326	0.0354
80	PSM	36.0688	-120.5962	0.957	0.0297
81	PSN	35.7878	-120.2951	0.390	-0.0487
82	PSR	35.8562	-120.2804	0.480	0.0015
83	PST	35.9307	-120.5148	0.559	-0.0701
84	PTA	35.3925	-120.7078	0.802	-0.1017
85	PTR	35.6541	-120.2133	0.594	-0.1175
86	PVC	35.9221	-120.5350	0.770	-0.0767
87	PWK	35.8145	-120.5119	0.470	0.1676
88	PWM	36.4327	-120.2124	0.045	-0.0490
89	RAMR	35.6360	-120.8698	0.414	0.0150
90	RMNB	36.0009	-120.4777	1.164	-0.0427
91	SCC	34.9409	-120.1730	0.565	0.3080
92	SCYB	36.0094	-120.5366	0.947	-0.0329
93	SIM	35.3502	-119.9965	0.578	0.0450
94	SMNB	35.9730	-120.5799	0.698	-0.0634
95	VARB	35.9261	-120.4471	0.475	0.1005
96	VCAB	35.9216	-120.5339	0.755	-0.1621
97	YEG	35.4366	-119.9601	0.907	0.0418

Appendix II Comparison of VELHYPO relocated events with results of HypoDD and HYPOINVERSE.

					hypoDD				HYPOINVERSE				VELHYPO			
S/N	Event ID	Mag	Date (yy/mm/dd)	hh:mm	Time (ss)	Lat (deg)	Long (deg)	Dept (km)	Time (ss)	Lat (deg)	Long (deg)	Dept (km)	Time (ss)	Lat (deg)	Long (deg)	Dept (km)
1	21075061	1.19	2000/01/01	05:19	4.10	36.0349	-120.5807	9.00	24.02	36.0390	-120.5773	9.37	23.57	36.0109	-120.6081	9.00
2	21075067	1.14	2000/01/01	06:50	7.03	35.9911	-120.5495	4.69	57.08	35.9897	-120.5488	4.76	56.60	35.9819	-120.5663	4.72
3	21075241	1.25	2000/01/02	10:57	3.36	36.2121	-120.7763	5.64	33.44	36.2063	-120.7857	5.98	32.72	36.2002	-120.7795	5.92
4	21075546	0.00	2000/01/03	17:41	6.00	35.9568	-120.5066	11.10	15.75	35.9503	-120.5055	13.17	14.90	35.9338	-120.5329	13.28
5	21076108	1.58	2000/01/07	09:59	3.79	36.1896	-120.7617	2.54	53.91	36.1858	-120.7720	2.97	53.53	36.1848	-120.7701	0.67
6	21076261	1.12	2000/01/08	05:31	7.92	35.9891	-120.5483	4.50	27.94	35.9890	-120.5455	4.39	27.85	35.9793	-120.5578	2.74
7	21076477	1.97	2000/01/09	23:18	0.75	36.2795	-120.8540	5.58	50.66	36.2812	-120.8505	7.14	50.69	36.2753	-120.8586	5.57
8	21077337	1.40	2000/01/13	13:00	0.79	36.2404	-120.8058	9.09	20.84	36.2403	-120.8080	9.37	20.99	36.2348	-120.8184	7.28
9	21077513	1.20	2000/01/14	13:23	2.46	35.8226	-120.3723	8.10	52.44	35.8215	-120.3717	8.57	52.40	35.8224	-120.3741	7.54
10	21077661	2.26	2000/01/15	10:29	2.81	35.9892	-120.5472	4.74	32.77	35.9883	-120.5472	5.40	32.70	35.9811	-120.5593	3.06
11	21077663	1.30	2000/01/15	10:34	8.64	35.9895	-120.5476	4.82	18.60	35.9923	-120.5455	5.17	18.46	35.9819	-120.5601	2.47
12	21077835	1.35	2000/01/16	03:11	8.18	36.0353	-120.6000	1.88	38.15	36.0395	-120.5977	3.04	37.57	36.0287	-120.6083	0.28
13	21078052	1.26	2000/01/17	13:50	8.20	36.0350	-120.5999	1.85	58.25	36.0398	-120.5940	3.08	57.90	36.0280	-120.6006	0.63
14	21078108	1.68	2000/01/17	19:29	1.79	35.9841	-120.4840	9.43	51.74	35.9862	-120.4802	9.60	51.79	35.9700	-120.5100	8.26
15	21078120	1.46	2000/01/17	20:70	1.20	36.0359	-120.5912	4.83	1.20	36.0367	-120.5893	4.61	0.62	36.0204	-120.6151	4.42
16	21078126	1.02	2000/01/17	20:31	8.80	36.0357	-120.5912	4.86	48.80	36.0382	-120.5863	4.28	48.36	36.0298	-120.5909	4.13
17	21078147	1.29	2000/01/17	22:10	6.65	35.9844	-120.4843	9.44	16.54	35.9890	-120.4820	9.15	16.43	35.9726	-120.5082	8.99
18	21078159	1.48	2000/01/17	23:30	5.79	35.9845	-120.4843	9.44	15.79	35.9885	-120.4773	9.48	15.72	35.9710	-120.5082	8.78
19	30221651	1.64	2000/01/18	06:19	6.05	35.8596	-120.4028	5.06	46.11	35.8580	-120.4035	5.35	45.79	35.8603	-120.4097	5.03
20	21078210	2.24	2000/01/18	06:50	7.23	35.8596	-120.4028	5.08	57.24	35.8573	-120.4037	5.42	57.04	35.8586	-120.4137	4.54
21	21078257	1.42	2000/01/18	11:36	9.46	36.0972	-120.6576	4.68	9.45	36.1028	-120.6523	4.81	9.16	36.0869	-120.6634	4.99
22	21078281	2.02	2000/01/18	14:18	9.30	36.0473	-120.6016	6.44	9.23	36.0452	-120.6035	6.73	9.14	36.0266	-120.6308	3.93
23	21078293	2.02	2000/01/18	17:80	2.66	36.1284	-120.6903	5.56	52.72	36.1212	-120.6950	5.73	52.42	36.1088	-120.7131	5.96
24	21078386	2.31	2000/01/19	03:20	3.90	35.8589	-120.4022	5.08	13.93	35.8568	-120.4025	5.51	13.50	35.8635	-120.4088	5.74
25	21078753	1.03	2000/01/20	17:60	2.12	36.0409	-120.5959	4.96	42.11	36.0432	-120.5918	4.24	42.21	36.0222	-120.6146	4.37
26	21079075	1.19	2000/01/21	19:36	0.41	35.9818	-120.4841	9.01	0.39	35.9832	-120.4793	8.99	0.18	35.9691	-120.5090	8.39
27	21079147	1.18	2000/01/22	05:44	3.32	35.9882	-120.5460	4.76	23.36	35.9887	-120.5458	5.33	23.01	35.9828	-120.5564	2.37
28	21079188	0.97	2000/01/22	10:30	8.19	36.0755	-120.6287	4.68	38.19	36.0773	-120.6258	4.60	37.88	36.0404	-120.6746	5.59
29	21079429	1.62	2000/01/23	03:60	5.32	36.2085	-120.7813	2.16	35.28	36.2035	-120.7862	2.12	35.44	36.2014	-120.7866	1.70
30	21079702	1.05	2000/01/24	23:30	7.81	35.7720	-120.3227	8.60	47.77	35.7707	-120.3215	8.45	47.59	35.7727	-120.3188	9.00
31	21080120	1.96	2000/01/27	17:13	4.96	35.9997	-120.5580	4.58	24.91	36.0007	-120.5565	5.17	24.77	35.9916	-120.5681	2.46
32	21080275	1.15	2000/01/28	03:20	8.69	36.0043	-120.5632	4.55	8.80	36.0045	-120.5635	4.52	8.28	35.9964	-120.5783	4.25
33	21080317	1.10	2000/01/28	04:20	2.85	35.8742	-120.4187	5.52	33.00	35.8740	-120.4193	5.53	32.91	35.8797	-120.4228	4.82
34	30221692	1.24	2000/01/28	06:48	6.76	35.9994	-120.5576	4.56	6.73	36.0003	-120.5553	4.92	6.56	35.9926	-120.5653	2.40
35	21080395	1.16	2000/01/28	13:13	4.49	35.7562	-120.3195	7.40	44.60	35.7545	-120.3187	7.03	44.74	35.7563	-120.3183	5.82
36	21080602	1.27	2000/01/29	14:50	7.93	36.1151	-120.6736	7.14	17.96	36.1102	-120.6803	7.00	17.04	36.1046	-120.6835	8.99
37	21080723	1.41	2000/01/30	05:56	8.07	36.0449	-120.6155	0.99	58.13	36.0475	-120.6112	0.90	57.97	36.0269	-120.6341	3.88
38	21080765	1.18	2000/01/30	12:15	0.73	35.9816	-120.4817	9.02	0.98	35.9788	-120.4835	8.60	1.03	35.9666	-120.5094	7.93
39	21081496	2.00	2000/02/04	01:39	1.76	36.0353	-120.6009	0.99	31.76	36.0368	-120.5995	0.85	31.51	36.0189	-120.6215	4.17
40	21081808	1.27	2000/02/06	11:50	5.59	36.2326	-120.7959	7.50	25.60	36.2315	-120.7967	7.91	25.48	36.2335	-120.7953	6.92
41	30504109	1.56	2000/02/10	13:56	4.86	36.0752	-120.6487	0.32	54.90	36.0795	-120.6465	0.18	54.97	36.0577	-120.6682	0.25
42	21082548	1.28	2000/02/11	14:59	6.35	36.0769	-120.5176	6.14	16.33	36.0782	-120.5142	4.33	15.62	36.0592	-120.5358	6.58
43	21083244	2.14	2000/02/17	08:52	9.84	36.0907	-120.5411	5.42	29.89	36.0898	-120.5440	6.27	29.83	36.0694	-120.5784	6.54
44	21084133	1.18	2000/02/24	10:45	9.94	35.7005	-120.2739	8.56	9.98	35.7015	-120.2735	7.99	9.83	35.6980	-120.2718	7.50
45	21084172	1.08	2000/02/24	18:44	8.58	35.8923	-120.4380	6.55	58.55	35.8945	-120.4365	6.73	58.63	35.8970	-120.4446	5.28
46	30221385	1.11	2000/02/26	05:29	8.54	36.0336	-120.5988	1.63	8.46	36.0353	-120.5958	1.40	8.15	36.0264	-120.5952	0.62
47	21084953	1.20	2000/03/02	4:60	1.00	35.9988	-120.5441	12.88	1.07	35.9975	-120.5413	12.56	0.99	35.9837	-120.5600	10.62
48	21085649	1.94	2000/03/07	19:50	6.68	36.1800	-120.7524	1.19	6.84	36.1885	-120.7433	3.83	6.65	36.1901	-120.7380	1.59
49	21086092	1.41	2000/03/11	03:59	1.95	36.2306	-120.7943	5.09	41.95	36.2310	-120.7948	8.19	42.07	36.2259	-120.8023	3.04
50	21086411	1.72	2000/03/12	23:14	0.40	35.9243	-120.4714	5.66	40.39	35.9247	-120.4703	5.71	40.20	35.9207	-120.4835	4.62
51	21086413	1.14	2000/03/12	23:17	5.60	35.9243	-120.4712	5.69	5.56	35.9245	-120.4692	5.57	5.49	35.9202	-120.4849	4.98
52	21086417	1.07	2000/03/12	23:40	9.80	35.9243	-120.4715	5.65	9.82	35.9242	-120.4730	5.51	9.18	35.9218	-120.4846	6.23
53	21086460	1.24	2000/03/13	08:57	5.04	36.0537	-120.6064	9.69	54.92	36.0582	-120.5987	10.00	55.07	36.0378	-120.6196	7.24
54	21086462	1.36	2000/03/13	09:10	0.60	36.0536	-120.6065	9.70	40.54	36.0583	-120.6007	10.01	40.66	36.0398	-120.6192	7.40
55	21086470	1.14	2000/03/13	10:46	6.00	36.0530	-120.6066	9.69	5.98	36.0578	-120.5957	9.35	5.89	36.0398	-120.6153	7.85
56	21086569	1.42	2000/03/14	08:30	7.45	36.1652	-120.7396	4.83	27.45	36.1675	-120.7353	5.61	27.23	36.1653	-120.7342	4.91
57	21086598	1.28	2000/03/14	17:34	8.95	35.8631	-120.4068	5.41	8.95	35.8623	-120.4068	5.36	8.80	35.8674	-120.4107	4.71
58	21086642	2.29	2000/03/14	23:34	7.91	35.9246	-120.4721	5.58	37.82	35.9238	-120.4717	5.90	37.88	35.9184	-120.4810	3.16
59	21087210	1.42	2000/03/18	11:00	2.41	36.2311	-120.7942	7.51	2.41	36.2313	-120.7952	8.06	2.36	36.2314	-120.7942	7.12
60	21088017	1.53	2000/03/23	14:45	0.54	35.9905	-120.5485	4.73	40.59	35.9913	-120.5473	5.31	40.38	35.9804	-120.5643	4.00
61	21088307	1.40	2000/03/25	16:50	1.73	36.0202	-120.5777	4.96	1.66	36.0213	-120.5758	5.23	1.42	36.0092	-120.5933	4.40
62	21088567	1.29	2000/03/27	00:56	7.61	36.0687	-120.6302	2.59	47.56	36.0750	-120.6220	3.51	47.22	36.0490	-120.6510	3.14
63	21089675	0.85	2000/04/02	03:30	7.23	35.8477	-120.3952	8.89	17.27	35.8455	-120.3952	8.68	17.36	35.8490	-120.3997	7.24
64	21090082	0.00	2000/04/04	4:90	5.21	35.9667	-120.5235	6.12	25.24	35.9680	-120.5217	5.87	25.17	35.9606	-120.5391	3.31
65	30221696	0.96	2000/04/07	21:29	2.21	35.9258	-120.4723	4.78	22.22	35.9262	-120.4710	4.70	22.08	35.9174	-120.4880	3.58
66	21091100	2.89	2000/04/08	06:51	2.31	35.8006	-120.3480	6.00	42.25	35.8003	-120.3472	6.79	41.94	35.7967	-120.3575	6.64
67	21091223	2.00	2000/04/09	03:59	9.54	36.1976	-120.7599	7.39	49.58	36.1930	-120.7637	8.19	49.48	36.1878	-120.7713	6.65
68	21091336	1.57	2000/04/09	23:27	1.62	36.0948	-120.6752	0.42	51.66	36.0958	-120.6742	0.09	51.55	36.0930	-120.6652	5.03
69	21091487	0.94	2000/04/10	19:52	9.15	36.0586	-120.6154	3.55	49.16	36.0607	-120.6113	3.38	48.70	36.0504	-120.6166	2.37
70	21092235	2.82	2000/04/15	13:06	6.28	36.1984	-120.7607	7.44	56.24	36.1965	-120.7633	8.36	56.10	36.1881	-120.7708	8.44
71	21092364	1.16	2000/04/16	08:57	5.95	36.0393	-120.5944	4.61	35.93	36.0420	-120.5878	4.18	35.75	36.0325	-120.5995	2.50
72	21092841	0.94	2000/04/19	18:28	5.60	36.0507	-120.6056	4.24	45.58	36.0527	-120.6015	4.16	44.90	36.0452	-120.6025	4.51

Appendix II Comparison of VELHYPO relocated events with results of HypoDD and HYPOINVERSE.

					hypoDD				HYPOINVERSE				VELHYPO			
S/N	Event ID	Mag	Date (yy/mm/dd)	hh:mm	Time (ss)	Lat (deg)	Long (deg)	Dept (km)	Time (ss)	Lat (deg)	Long (deg)	Dept (km)	Time (ss)	Lat (deg)	Long (deg)	Dept (km)
73	21092877	1.63	2000/04/19	23:36	8.79	35.9306	-120.4791	5.46	38.76	35.9288	-120.4793	5.34	38.44	35.9212	-120.4960	4.48
74	21093272	1.17	2000/04/22	09:51	4.50	35.7486	-120.2962	7.32	4.50	35.7475	-120.2935	6.95	4.66	35.7467	-120.2919	5.71
75	21093319	0.95	2000/04/22	17:31	5.08	35.9977	-120.5596	3.45	15.04	35.9973	-120.5603	4.91	14.74	35.9854	-120.5753	4.84
76	21093986	1.16	2000/04/26	19:28	7.18	36.0218	-120.5633	10.23	7.04	36.0228	-120.5628	10.65	7.12	36.0063	-120.5814	8.40
77	21094494	2.87	2000/04/29	17:50	1.05	35.7929	-120.3438	9.72	41.07	35.7937	-120.3452	9.64	40.40	35.7832	-120.3656	10.45
78	21094985	1.45	2000/05/02	19:14	1.18	36.0528	-120.6073	4.35	41.13	36.0580	-120.6005	4.79	40.98	36.0460	-120.6167	2.71
79	30221801	1.21	2000/05/03	04:46	8.09	36.0378	-120.5926	4.78	8.05	36.0407	-120.5880	4.75	7.86	36.0269	-120.6079	0.64
80	21096053	2.77	2000/05/07	15:50	2.48	36.2504	-120.8144	5.16	32.48	36.2488	-120.8157	6.43	32.49	36.2468	-120.8230	4.14
81	21096061	3.10	2000/05/07	16:50	0.68	36.2547	-120.8192	5.34	40.49	36.2502	-120.8157	6.42	40.59	36.2513	-120.8229	3.12
82	21096101	1.27	2000/05/08	01:47	5.56	36.2313	-120.7967	4.82	45.62	36.2272	-120.8023	4.64	45.68	36.2303	-120.8038	2.90
83	21096133	1.41	2000/05/08	08:40	4.61	36.0377	-120.5925	4.72	44.59	36.0400	-120.5898	4.79	44.38	36.0220	-120.6175	4.41
84	30221823	1.05	2000/05/09	07:14	4.90	35.9235	-120.4794	4.75	54.80	35.9267	-120.4765	4.73	54.63	35.9181	-120.4944	4.41
85	21096586	1.14	2000/05/10	01:36	3.15	35.9644	-120.6847	11.55	23.00	35.9730	-120.6718	12.65	23.10	35.9565	-120.6876	7.77
86	21096610	1.23	2000/05/10	08:10	4.80	35.9645	-120.6843	11.55	24.59	35.9727	-120.6722	12.80	24.66	35.9576	-120.6881	7.88
87	21096614	0.00	2000/05/10	08:48	8.06	35.9647	-120.6839	11.55	7.97	35.9782	-120.6642	12.32	7.87	35.9576	-120.6895	8.11
88	21096723	1.35	2000/05/10	23:33	1.79	36.2236	-120.7874	5.29	31.91	36.2118	-120.7970	7.57	31.69	36.2172	-120.7950	8.90
89	21096834	2.11	2000/05/11	06:45	9.94	36.2245	-120.7871	5.16	40.00	36.2190	-120.7942	8.11	40.00	36.2185	-120.7982	1.52
90	21097036	1.40	2000/05/12	12:41	8.18	36.1940	-120.7563	7.17	18.10	36.1997	-120.7525	8.20	17.78	36.2015	-120.7516	8.59
91	21097038	1.11	2000/05/12	13:22	4.01	35.9833	-120.5190	8.12	4.00	35.9812	-120.5203	8.46	3.81	35.9700	-120.5386	7.15
92	21097324	1.33	2000/05/13	11:43	6.33	35.9996	-120.5612	3.25	36.36	36.0002	-120.5607	4.40	36.09	35.9926	-120.5731	2.40
93	30221844	0.00	2000/05/13	22:00	7.31	36.0603	-120.6104	10.04	37.43	36.0615	-120.6080	8.93	37.10	35.9778	-120.7138	8.42
94	21097574	1.84	2000/05/14	17:27	8.39	35.9982	-120.5597	3.25	58.42	35.9985	-120.5595	4.44	58.15	35.9902	-120.5705	2.50
95	21097627	1.10	2000/05/15	01:40	5.70	35.7860	-120.3258	4.27	15.72	35.7858	-120.3267	3.40	15.61	35.7863	-120.3252	1.98
96	21097904	1.12	2000/05/16	08:90	6.95	35.9932	-120.5515	5.10	6.94	35.9962	-120.5475	5.49	6.49	35.9864	-120.5598	4.91
97	21098162	0.92	2000/05/17	16:47	3.57	35.9627	-120.5113	3.61	43.58	35.9662	-120.5075	3.77	43.54	35.9604	-120.5223	2.78
98	21098897	1.75	2000/05/20	20:38	6.45	36.1717	-120.7454	2.99	46.44	36.1768	-120.7355	4.26	46.19	36.1784	-120.7320	3.16
99	21098914	1.33	2000/05/20	22:56	8.57	36.0132	-120.5742	3.41	28.71	36.0152	-120.5710	3.86	28.08	36.0077	-120.5858	4.97
100	21099029	1.55	2000/05/21	05:43	1.26	36.0210	-120.5790	4.66	11.23	36.0228	-120.5757	5.06	10.94	36.0139	-120.5916	4.23
101	21099088	1.70	2000/05/21	09:80	7.55	36.0830	-120.6438	2.87	57.53	36.0893	-120.6367	4.14	57.15	36.0779	-120.6486	4.01
102	21099477	2.77	2000/05/22	20:10	3.38	36.0139	-120.5724	4.31	13.33	36.0140	-120.5720	5.17	13.21	36.0049	-120.5828	2.50
103	21099478	2.31	2000/05/22	20:13	9.35	36.0132	-120.5715	4.31	9.43	36.0122	-120.5735	5.08	9.27	36.0030	-120.5859	2.51
104	21099830	1.26	2000/05/24	01:38	7.96	35.9260	-120.4734	5.17	48.05	35.9273	-120.4707	5.04	47.63	35.9203	-120.4873	5.24
105	21099834	1.05	2000/05/24	02:00	4.73	35.9260	-120.4734	5.15	34.62	35.9272	-120.4710	5.26	34.29	35.9207	-120.4894	5.28
106	21099940	1.10	2000/05/24	08:26	7.87	35.9259	-120.4732	5.16	57.89	35.9267	-120.4713	4.73	57.39	35.9214	-120.4855	4.98
107	21100172	1.42	2000/05/25	09:26	3.07	36.0113	-120.5690	4.55	43.05	36.0128	-120.5663	4.98	42.80	36.0047	-120.5813	4.06
108	30221931	1.10	2000/05/25	09:27	4.16	36.0116	-120.5693	4.54	34.17	36.0125	-120.5708	4.43	33.58	36.0054	-120.5751	4.93
109	21100493	1.55	2000/05/27	12:28	1.05	36.0439	-120.6028	16.82	51.13	36.0380	-120.5993	19.19	52.67	35.9923	-120.5639	0.99
110	21100613	1.44	2000/05/28	03:51	8.24	36.0704	-120.6200	5.55	58.14	36.0698	-120.6190	5.09	57.67	36.0525	-120.6379	6.41
111	21100685	0.78	2000/05/28	14:37	3.56	35.8154	-120.3579	4.98	23.57	35.8153	-120.3578	5.18	23.16	35.8178	-120.3595	5.14
112	21100860	1.11	2000/05/29	16:10	5.24	36.0206	-120.5775	4.89	25.27	36.0225	-120.5745	4.76	24.96	36.0122	-120.5871	4.18
113	21102190	0.85	2000/06/06	06:10	4.20	35.7616	-120.3120	8.24	34.27	35.7610	-120.3152	7.19	34.07	35.7616	-120.3128	7.14
114	21102867	1.39	2000/06/09	06:60	6.74	35.9146	-120.4668	5.64	36.72	35.9168	-120.4638	5.32	36.53	35.9115	-120.4791	4.08
115	21103132	1.20	2000/06/10	18:30	4.52	35.9725	-120.5267	7.19	34.49	35.9733	-120.5220	7.27	34.22	35.9653	-120.5383	5.92
116	21103339	1.74	2000/06/12	03:18	1.35	36.1030	-120.6772	3.07	51.38	36.0998	-120.6805	3.48	50.46	36.0947	-120.6830	5.49
117	21103675	1.34	2000/06/14	3:21	5.21	36.2491	-120.8147	5.00	5.24	36.2462	-120.8138	5.93	4.57	36.2368	-120.8131	6.52
118	21103782	1.29	2000/06/14	18:47	2.31	36.1953	-120.7575	7.36	52.46	36.1902	-120.7630	7.66	52.60	36.1877	-120.7630	5.98
119	21103793	1.74	2000/06/14	20:15	6.36	36.1064	-120.6780	2.75	26.43	36.1000	-120.6822	3.16	25.41	36.0938	-120.6912	5.98
120	21103852	0.00	2000/06/15	08:14	2.24	36.1951	-120.7578	7.38	12.22	36.1970	-120.7552	8.15	12.30	36.1971	-120.7516	6.01
121	21104833	1.96	2000/06/20	23:44	1.35	36.0620	-120.6370	0.32	1.52	36.0617	-120.6345	0.03	1.31	36.0467	-120.6534	3.61
122	21104837	1.02	2000/06/21	00:90	0.86	36.0053	-120.5634	4.51	20.96	36.0065	-120.5627	4.91	20.75	35.9899	-120.5907	6.67
123	21104848	1.01	2000/06/21	01:55	4.38	36.0331	-120.5888	5.02	24.42	36.0348	-120.5888	4.16	24.39	36.0172	-120.6030	4.64
124	21104851	1.87	2000/06/21	03:10	9.07	36.0678	-120.6304	1.94	19.05	36.0665	-120.6327	1.24	18.74	36.0556	-120.6468	3.25
125	21104861	0.94	2000/06/21	06:26	8.46	36.0678	-120.6303	2.01	18.49	36.0707	-120.6238	2.45	17.91	36.0588	-120.6321	1.59
126	21105803	1.00	2000/06/25	06:90	2.60	35.8302	-120.3781	5.64	22.54	35.8295	-120.3773	5.18	22.60	35.8335	-120.3798	3.77
127	21106055	2.37	2000/06/26	15:50	9.32	36.0350	-120.5895	8.31	39.30	36.0363	-120.5880	8.53	39.15	36.0244	-120.6056	6.92
128	21106056	1.89	2000/06/26	15:56	9.41	36.1015	-120.6590	7.96	59.61	36.0950	-120.6613	7.61	59.04	36.0890	-120.6727	8.62
129	21106068	1.40	2000/06/26	16:46	2.63	36.1015	-120.6603	7.91	12.76	36.0918	-120.6655	6.86	12.07	36.0973	-120.6615	8.98
130	21106087	0.97	2000/06/26	20:40	0.83	36.1001	-120.6605	7.65	41.21	36.0932	-120.6607	5.39	40.89	36.0945	-120.6701	8.37
131	21106167	1.29	2000/06/27	05:27	2.24	35.9940	-120.5537	4.37	52.22	35.9943	-120.5525	4.85	52.08	35.9869	-120.5618	1.50
132	21106173	1.11	2000/06/27	06:43	3.55	35.9992	-120.5610	3.14	23.56	36.0000	-120.5598	3.88	23.49	35.9868	-120.5776	4.18
133	21106399	1.35	2000/06/27	21:26	1.77	36.2250	-120.7393	7.08	32.13	36.2170	-120.7560	6.72	32.12	36.2219	-120.7465	5.17
134	21107670	1.03	2000/07/04	00:35	8.92	35.9266	-120.4744	5.43	38.89	35.9283	-120.4722	5.43	38.49	35.9194	-120.4890	5.29
135	21107693	1.18	2000/07/04	07:42	5.02	36.0378	-120.5922	4.72	4.98	36.0408	-120.5885	4.46	4.62	36.0292	-120.6003	2.27
136	21108025	1.15	2000/07/06	07:31	4.76	35.9838	-120.5352	7.48	24.68	35.9878	-120.5308	7.68	24.58	35.9747	-120.5481	5.80
137	21108028	1.15	2000/07/06	07:37	6.19	35.9837	-120.5350	7.47	6.19	35.9853	-120.5327	7.41	6.02	35.9736	-120.5481	5.80
138	21108170	1.04	2000/07/07	03:29	6.03	36.0107	-120.5681	4.56	16.10	36.0108	-120.5700	4.05	15.99	35.9972	-120.5812	2.69
139	21108500	1.55	2000/07/09	04:17	1.16	36.0120	-120.5677	4.74	41.08	36.0127	-120.5658	5.26	40.78	36.0050	-120.5808	4.52
140	21108525	1.97	2000/07/09	10:59	0.80	36.1948	-120.7565	7.17	10.84	36.1927	-120.7577	7.74	10.76	36.1855	-120.7644	6.31
141	21109067	1.13	2000/07/12	09:10	1.26	36.0533	-120.6049	7.73	31.31	36.0543	-120.6028	7.94	31.25	36.0399	-120.6158	6.35
142	21109780	1.60	2000/07/14	17:22	4.96	36.0395	-120.6068	1.12	15.04	36.0448	-120.6000	1.65	14.71	36.0252	-120.6183	4.29
143	21110287	1.53	2000/07/16	22:31	2.39	36.0301	-120.5872	4.79	2.35	36.0295	-120.5898	4.68	1.92	36.0254	-120.5876	3.11
144	21110308	1.74	2000/07/17	04:25	7.40	36.0231	-120.5855	0.40	57.48	36.0258	-120.5817	0.11	57.19	36.0207	-120.5906	3.22

Appendix II Comparison of VELHYPO relocated events with results of HypoDD and HYPOINVERSE.

					hypoDD				HYPOINVERSE				VELHYPO			
S/N	Event ID	Mag	Date (yy/mm/dd)	hh:mm	Time (ss)	Lat (deg)	Long (deg)	Dept (km)	Time (ss)	Lat (deg)	Long (deg)	Dept (km)	Time (ss)	Lat (deg)	Long (deg)	Dept (km)
145	21110520	1.16	2000/07/17	19:42	8.49	36.1634	-120.7344	4.95	38.48	36.1627	-120.7362	6.11	38.05	36.1681	-120.7241	6.40
146	21110804	1.26	2000/07/19	01:54	6.53	36.0395	-120.5946	4.47	56.54	36.0407	-120.5948	3.96	56.33	36.0248	-120.6109	4.15
147	21110816	1.17	2000/07/19	03:32	1.72	36.0397	-120.5942	4.64	31.71	36.0425	-120.5877	4.13	31.42	36.0328	-120.5947	2.49
148	21111281	1.12	2000/07/21	05:50	4.79	36.0101	-120.5651	5.54	34.82	36.0122	-120.5628	5.70	34.58	36.0013	-120.5743	5.08
149	21111715	2.00	2000/07/24	08:41	8.28	36.0961	-120.6625	3.61	48.15	36.1010	-120.6578	4.59	47.84	36.0925	-120.6640	3.96
150	21111901	0.92	2000/07/25	18:70	8.06	35.9648	-120.5134	3.98	18.21	35.9652	-120.5158	3.78	18.08	35.9597	-120.5329	1.09
151	21113491	0.95	2000/07/29	12:50	4.38	35.9220	-120.4674	5.25	44.34	35.9190	-120.4702	5.02	44.02	35.9143	-120.4904	4.55
152	21113565	1.09	2000/07/29	19:24	2.74	35.7772	-120.4444	10.76	2.72	35.7738	-120.4407	11.04	1.87	35.7731	-120.4527	13.70
153	21178944	0.94	2000/07/30	00:32	2.79	36.0088	-120.5839	5.44	32.72	36.0113	-120.5855	5.71	32.50	35.9963	-120.6160	6.41
154	21114207	1.20	2000/07/31	17:47	1.77	35.8840	-120.4320	10.89	21.97	35.8848	-120.4322	10.45	21.75	35.8838	-120.4454	9.95
155	21114751	1.39	2000/08/03	12:26	3.50	36.0872	-120.6499	2.82	23.42	36.0963	-120.6417	4.18	23.04	36.0845	-120.6515	4.47
156	21181087	1.02	2000/08/05	15:43	3.07	35.9786	-120.5398	2.91	13.08	35.9768	-120.5405	4.20	12.80	35.9705	-120.5494	1.46
157	21181091	0.00	2000/08/06	02:45	8.33	35.9696	-120.5407	3.03	58.41	35.9757	-120.5447	1.36	57.93	35.9651	-120.5478	1.48
158	21116859	1.41	2000/08/06	19:15	1.00	36.0360	-120.5910	4.68	21.05	36.0360	-120.5907	4.09	20.75	36.0169	-120.6117	3.31
159	21116889	1.64	2000/08/07	00:48	9.99	36.2719	-120.8441	5.64	50.00	36.2685	-120.8435	6.84	49.91	36.2712	-120.8461	5.15
160	21181099	1.10	2000/08/08	07:60	8.50	36.0264	-120.5878	2.54	58.51	36.0298	-120.5802	2.78	58.39	36.0184	-120.5946	0.99
161	21181100	0.00	2000/08/08	07:14	9.74	35.9493	-120.5028	9.85	59.83	35.9450	-120.5090	9.34	59.73	35.9480	-120.5178	8.13
162	21181101	0.94	2000/08/08	11:51	4.27	36.0589	-120.6244	1.93	34.30	36.0658	-120.6120	3.23	33.52	36.0519	-120.6227	1.90
163	21119260	1.13	2000/08/10	15:10	4.50	35.9843	-120.5419	2.42	44.49	35.9870	-120.5393	3.43	44.18	35.9755	-120.5534	0.97
164	21119268	2.14	2000/08/10	15:24	3.85	35.9844	-120.5424	2.49	13.89	35.9828	-120.5445	4.26	13.65	35.9770	-120.5532	1.51
165	21181106	0.00	2000/08/11	16:47	1.20	35.9254	-120.4767	5.06	11.23	35.9245	-120.4768	4.89	10.97	35.9203	-120.4973	4.51
166	21119996	0.97	2000/08/15	08: 80	7.76	35.8931	-120.4405	11.15	17.66	35.8935	-120.4247	11.49	17.45	35.8992	-120.4538	10.36
167	21120120	1.66	2000/08/15	20:58	6.58	35.9986	-120.5603	3.24	56.55	35.9995	-120.5578	4.11	56.29	35.9914	-120.5705	2.48
168	21120129	1.44	2000/08/15	21:32	7.77	36.0711	-120.6331	3.04	47.70	36.0778	-120.6242	4.04	47.45	36.0590	-120.6411	1.58
169	21120229	1.06	2000/08/16	09:30	9.09	36.1434	-120.7128	5.66	39.16	36.1348	-120.7205	6.06	39.23	36.1283	-120.7262	5.07
170	21120264	1.72	2000/08/16	17:20	2.26	35.9991	-120.5607	3.37	52.20	35.9990	-120.5610	4.54	51.71	35.9908	-120.5755	4.55
171	21120513	1.29	2000/08/18	12:54	1.05	36.0049	-120.5628	4.55	31.01	36.0072	-120.5577	4.48	30.41	35.9998	-120.5660	4.51
172	21120728	0.95	2000/08/20	09:50	9.40	36.0065	-120.5633	5.13	29.23	36.0075	-120.5642	6.35	28.80	35.9970	-120.5759	5.75
173	21120864	1.32	2000/08/21	11:60	6.30	36.2224	-120.7999	6.28	26.25	36.2177	-120.8028	5.87	26.09	36.2195	-120.8029	5.21
174	21120928	1.42	2000/08/21	18:00	5.68	35.8911	-120.4380	11.19	15.74	35.8912	-120.4383	10.77	15.55	35.8874	-120.4548	9.96
175	21120982	1.39	2000/08/22	00:39	3.12	36.0108	-120.5726	3.15	3.01	36.0118	-120.5717	4.14	2.48	35.9985	-120.5860	4.35
176	21216173	2.10	2000/08/23	04:44	9.58	36.0025	-120.5606	4.59	29.63	36.0040	-120.5592	5.26	29.20	35.9969	-120.5701	4.61
177	21121712	1.42	2000/08/26	05:28	3.31	35.9613	-120.5115	3.16	43.14	35.9608	-120.5113	4.12	42.96	35.9514	-120.5299	2.57
178	21181115	0.95	2000/08/26	10:14	2.04	35.8853	-120.4327	6.41	22.12	35.8890	-120.4292	6.28	21.96	35.8865	-120.4429	4.66
179	21121831	1.16	2000/08/26	21:11	0.20	35.9986	-120.5601	2.98	50.03	36.0037	-120.5538	2.78	49.79	35.9916	-120.5658	2.51
180	21121853	1.14	2000/08/27	01:30	1.89	35.9280	-120.4766	5.01	11.97	35.9307	-120.4745	5.07	11.20	35.9270	-120.4887	5.78
181	21121980	1.37	2000/08/27	18:11	6.55	36.2885	-120.7828	7.34	16.70	36.2862	-120.7857	8.78	16.39	36.2823	-120.7857	9.00
182	21122084	1.40	2000/08/28	06:32	2.60	36.2606	-120.8301	8.54	12.49	36.2593	-120.8287	9.15	12.23	36.2646	-120.8281	9.52
183	21122906	1.46	2000/08/31	09:10	6.53	35.8811	-120.4284	10.23	36.58	35.8795	-120.4298	10.12	36.49	35.8766	-120.4451	8.99
184	21123211	1.32	2000/09/02	01:52	8.03	36.2326	-120.7959	7.50	28.13	36.2298	-120.8027	7.84	28.15	36.2332	-120.7977	6.10
185	21123402	1.12	2000/09/03	10:13	6.82	36.0337	-120.5984	0.57	46.82	36.0358	-120.6040	0.25	46.44	36.0137	-120.6221	5.48
186	21181735	0.00	2000/09/03	15:80	4.85	35.9423	-120.4968	13.86	34.95	35.9367	-120.5082	13.54	34.79	35.9413	-120.5107	11.93
187	21181736	0.00	2000/09/03	15:54	7.37	35.9579	-120.5193	11.01	7.48	35.9527	-120.5250	10.55	7.51	35.9610	-120.5269	8.87
188	21123510	1.41	2000/09/03	22:27	8.94	35.9383	-120.4865	5.60	58.94	35.9380	-120.4828	5.62	58.45	35.9309	-120.4986	5.56
189	21123520	1.02	2000/09/03	23:17	9.07	35.9477	-120.4979	4.76	19.06	35.9498	-120.4953	4.60	18.47	35.9432	-120.5122	4.83
190	21123713	1.02	2000/09/05	10:80	4.20	36.0338	-120.5899	4.61	44.19	36.0360	-120.5838	4.16	44.03	36.0256	-120.5935	2.09
191	21123733	1.58	2000/09/05	15:80	2.05	36.2686	-120.7149	8.17	32.22	36.2622	-120.7197	8.07	32.40	36.2633	-120.7210	5.31
192	21181737	1.11	2000/09/05	22:40	1.90	36.0246	-120.5804	4.99	41.94	36.0273	-120.5768	4.52	41.93	36.0172	-120.5821	2.45
193	21123865	1.35	2000/09/06	05:41	3.56	36.1253	-120.6870	7.84	13.61	36.1235	-120.6892	7.40	12.87	36.1125	-120.6998	8.37
194	21123888	1.81	2000/09/06	10:40	1.88	35.9579	-120.5065	11.15	41.87	35.9570	-120.5065	11.53	41.87	35.9480	-120.5260	9.00
195	21123906	1.16	2000/09/06	13:90	5.50	36.0438	-120.5998	4.60	15.49	36.0465	-120.5952	4.26	15.04	36.0362	-120.6027	3.38
196	21123924	2.37	2000/09/06	16:40	4.37	35.8441	-120.3833	4.19	54.32	35.8418	-120.3835	4.49	53.92	35.8458	-120.3850	4.07
197	21124008	1.13	2000/09/06	20:24	9.54	35.8447	-120.3840	4.20	39.59	35.8443	-120.3862	3.90	39.03	35.8460	-120.3845	4.36
198	21124291	2.35	2000/09/08	22:10	0.97	36.0493	-120.6071	3.55	20.95	36.0460	-120.6097	5.50	20.09	36.0130	-120.6558	7.54
199	21124426	1.57	2000/09/09	20:23	8.02	35.7791	-120.3289	8.50	38.03	35.7778	-120.3283	8.67	37.79	35.7786	-120.3325	9.00
200	21124433	1.27	2000/09/09	20:42	3.34	35.7788	-120.3285	8.48	33.38	35.7767	-120.3280	8.59	33.10	35.7748	-120.3317	9.00
201	21124481	2.35	2000/09/10	11:15	8.06	36.0299	-120.5878	4.65	48.02	36.0317	-120.5838	5.24	47.75	36.0209	-120.6008	4.31
202	21124484	1.85	2000/09/10	11:27	7.96	36.0291	-120.5871	4.65	47.90	36.0322	-120.5833	5.15	47.74	36.0223	-120.6004	2.60
203	21181739	0.00	2000/09/11	08:26	9.30	35.9790	-120.5340	11.55	29.36	35.9747	-120.5410	11.91	29.31	35.9634	-120.5602	9.63
204	21181742	0.95	2000/09/12	03:80	1.87	36.0663	-120.6350	1.74	11.85	36.0683	-120.6313	1.66	11.62	36.0583	-120.6382	0.94
205	21124732	1.29	2000/09/12	18:00	2.10	36.2708	-120.8456	4.84	32.08	36.2628	-120.8523	6.34	31.95	36.2590	-120.8552	5.30
206	21124930	1.50	2000/09/13	04:53	6.26	36.0138	-120.5701	4.82	36.28	36.0153	-120.5675	5.37	36.00	36.0073	-120.5842	4.54
207	21125208	1.19	2000/09/14	03:22	0.92	36.0649	-120.6269	2.23	20.89	36.0688	-120.6227	2.56	20.33	36.0544	-120.6351	0.51
208	21125239	1.40	2000/09/14	10:90	7.52	36.2365	-120.8017	7.72	7.50	36.2360	-120.8040	8.58	7.41	36.2490	-120.7976	7.22
209	21125247	1.38	2000/09/14	12:26	3.83	36.1006	-120.6604	4.72	13.75	36.1058	-120.6552	5.04	13.58	36.0928	-120.6617	4.59
210	21125281	1.59	2000/09/14	18:21	2.10	36.0692	-120.6302	2.86	52.08	36.0738	-120.6235	3.42	51.67	36.0584	-120.6379	1.52
211	21125305	1.02	2000/09/14	22:42	5.24	36.0359	-120.5907	4.84	5.22	36.0385	-120.5850	4.33	4.88	36.0273	-120.6009	0.67
212	21125419	1.41	2000/09/15	23:49	1.01	36.1963	-120.7606	6.11	51.00	36.1895	-120.7708	6.22	51.11	36.1900	-120.7649	3.57
213	21125455	1.22	2000/09/16	06:24	3.35	36.0033	-120.5581	6.00	33.38	36.0038	-120.5560	5.94	33.31	35.9923	-120.5705	4.81
214	21125505	2.62	2000/09/16	15:50	6.03	36.0039	-120.5622	4.61	6.01	36.0045	-120.5618	5.32	5.48	35.9965	-120.5766	5.13
215	21181749	1.09	2000/09/16	17:21	0.97	36.0019	-120.5632	4.90	40.99	36.0020	-120.5645	5.77	40.84	35.9900	-120.5772	4.80
216	21125707	1.39	2000/09/18	07:53	2.69	36.2315	-120.7958	8.53	42.95	36.2128	-120.8063	8.02	42.87	36.2312	-120.7991	7.86

Appendix II Comparison of VELHYPO relocated events with results of HypoDD and HYPOINVERSE.

					hypoDD				HYPOINVERSE				VELHYPO			
S/N	Event ID	Mag	Date (yy/mm/dd)	hh:mm	Time (ss)	Lat (deg)	Long (deg)	Dept (km)	Time (ss)	Lat (deg)	Long (deg)	Dept (km)	Time (ss)	Lat (deg)	Long (deg)	Dept (km)
217	21125839	1.49	2000/09/19	02:39	5.16	36.2318	-120.7951	8.88	5.31	36.2253	-120.8075	8.88	5.25	36.2207	-120.8175	7.25
218	21126003	1.26	2000/09/20	03:23	41.29	35.8790	-120.4262	10.04	41.30	35.8753	-120.4302	9.69	40.75	35.8832	-120.4385	10.17
219	30222216	2.78	2000/09/21	18:70	34.22	35.8494	-120.3960	6.66	34.15	35.8468	-120.3948	6.84	33.87	35.8466	-120.4044	6.40
220	30222214	3.28	2000/09/21	18:80	58.54	35.8501	-120.3969	6.70	58.63	35.8472	-120.3955	6.91	58.28	35.8470	-120.4051	6.69
221	30222215	2.47	2000/09/21	18:90	59.82	35.8468	-120.3933	6.66	59.76	35.8462	-120.3932	6.79	59.57	35.8464	-120.4026	6.02
222	21126282	1.11	2000/09/21	18:18	58.00	36.0225	-120.5804	4.65	57.96	36.0247	-120.5780	5.14	57.39	36.0172	-120.5863	4.57
223	21126285	1.10	2000/09/21	18:28	55.21	35.9908	-120.5491	4.89	55.25	35.9922	-120.5458	5.05	54.90	35.9814	-120.5586	4.36
224	21126687	1.38	2000/09/24	05:54	56.38	36.2461	-120.7430	5.42	56.63	36.2388	-120.7588	5.42	56.59	36.2427	-120.7487	2.76
225	21181763	0.95	2000/09/24	12:32	55.47	36.0366	-120.6063	0.11	55.61	36.0383	-120.5990	0.03	54.85	36.0331	-120.6048	0.14
226	21126805	1.56	2000/09/25	06:47	0.48	36.0153	-120.5722	4.53	0.62	36.0158	-120.5723	5.23	0.37	36.0090	-120.5854	4.10
227	21126815	1.53	2000/09/25	08:54	31.83	35.9954	-120.5538	5.05	31.84	35.9942	-120.5543	5.66	31.52	35.9858	-120.5684	4.68
228	21126817	1.12	2000/09/25	08:58	46.96	35.9951	-120.5536	5.08	46.86	35.9950	-120.5518	5.45	46.82	35.9865	-120.5590	1.50
229	21182914	0.00	2000/09/27	15:00	37.01	35.8945	-120.4671	12.27	37.13	35.9013	-120.4415	9.65	37.18	35.9056	-120.4671	9.23
230	21127940	1.42	2000/10/01	03:13	23.08	35.8335	-120.3513	7.50	23.35	35.8553	-120.3585	6.79	23.22	35.8864	-120.3341	7.16
231	21128050	1.37	2000/10/02	04:49	43.76	35.8490	-120.3956	6.64	43.76	35.8465	-120.3958	6.59	43.47	35.8478	-120.4055	6.56
232	30222260	1.41	2000/10/02	04:49	51.33	35.8719	-120.3390	9.42	51.39	35.8683	-120.3573	9.19	51.73	35.8528	-120.3963	6.76
233	21128080	1.53	2000/10/02	10:20	43.08	36.0130	-120.5691	4.82	43.04	36.0135	-120.5683	5.38	42.73	36.0053	-120.5811	4.72
234	21182926	1.11	2000/10/02	14:51	30.42	36.0151	-120.5712	4.69	30.44	36.0163	-120.5727	4.98	30.41	36.0066	-120.5745	2.88
235	21128279	1.92	2000/10/03	21:19	33.54	36.1906	-120.7634	2.20	33.66	36.1858	-120.7742	3.08	33.37	36.1887	-120.7636	0.50
236	21128295	1.27	2000/10/04	01:13	16.06	36.0000	-120.5458	12.31	16.05	36.0030	-120.5388	12.37	16.02	35.9886	-120.5616	10.28
237	21128702	1.92	2000/10/06	04:47	12.02	36.0108	-120.5670	4.79	11.97	36.0113	-120.5663	5.61	11.71	36.0018	-120.5822	4.45
238	30222281	1.11	2000/10/06	13:45	5.51	36.0025	-120.5603	4.62	5.46	36.0038	-120.5588	5.32	5.16	35.9927	-120.5724	4.79
239	21129114	1.11	2000/10/08	17:39	10.07	36.0048	-120.5616	5.53	10.01	36.0055	-120.5603	6.12	9.76	35.9936	-120.5750	5.75
240	21129198	1.25	2000/10/09	07:22	36.89	36.0059	-120.5635	6.76	36.91	36.0080	-120.5613	6.78	36.67	35.9986	-120.5774	5.58
241	21129250	1.37	2000/10/09	20:27	1.89	35.9622	-120.5106	10.89	1.92	35.9623	-120.5115	11.03	2.07	35.9507	-120.5330	8.26
242	21129267	1.12	2000/10/10	01:39	27.92	36.0126	-120.5701	4.47	27.90	36.0142	-120.5662	4.38	27.29	36.0019	-120.6026	7.81
243	21129552	1.92	2000/10/12	15:36	59.40	36.0480	-120.6024	4.26	59.29	36.0512	-120.5975	4.69	59.07	36.0396	-120.6187	2.50
244	21182946	0.95	2000/10/13	21:50	1.77	35.8946	-120.4406	6.37	1.76	35.8968	-120.4398	6.32	1.81	35.8981	-120.4502	4.24
245	21129822	1.35	2000/10/14	16:21	10.51	36.0568	-120.6097	6.41	10.45	36.0595	-120.6072	6.55	10.57	36.0431	-120.6280	2.50
246	21129896	1.07	2000/10/15	05:54	6.18	35.7966	-120.3465	11.59	6.29	35.7828	-120.3520	10.24	6.34	35.7951	-120.3485	10.59
247	21129950	1.29	2000/10/15	14:26	9.01	35.7964	-120.3463	11.57	9.08	35.7958	-120.3468	11.43	9.03	35.7993	-120.3535	11.15
248	21129980	1.54	2000/10/15	20:30	15.91	35.7967	-120.3465	11.61	16.01	35.7958	-120.3457	11.73	16.00	35.7964	-120.3518	10.80
249	21130021	1.67	2000/10/16	05:47	32.77	35.9429	-120.4885	10.98	32.75	35.9415	-120.4883	11.05	32.82	35.9329	-120.5119	9.00
250	21130135	1.11	2000/10/17	06:44	59.77	36.0207	-120.5788	4.63	59.66	36.0240	-120.5752	4.93	59.25	36.0152	-120.5910	4.94
251	21130289	1.14	2000/10/18	03:28	20.09	35.9933	-120.5512	4.96	20.09	35.9907	-120.5497	5.23	19.99	35.9824	-120.5603	2.86
252	21130308	1.31	2000/10/18	07:25	41.44	36.2482	-120.8160	8.73	41.47	36.2475	-120.8193	9.19	41.56	36.2491	-120.8190	7.15
253	21130321	1.36	2000/10/18	12:44	22.93	35.9426	-120.4881	11.00	22.93	35.9438	-120.4855	11.06	23.18	35.9306	-120.5110	8.46
254	21182957	0.00	2000/10/19	00:40	49.74	36.0552	-120.6107	5.12	49.74	36.0555	-120.6085	5.24	49.73	36.0426	-120.6216	2.13
255	21131238	1.11	2000/10/24	18:18	34.71	35.9288	-120.4772	5.26	34.76	35.9252	-120.4713	5.15	34.05	35.9207	-120.4904	5.85
256	21131271	0.94	2000/10/25	00:54	16.45	36.0450	-120.5962	5.06	16.49	36.0460	-120.5928	4.73	16.46	36.0321	-120.6144	1.07
257	21131273	1.14	2000/10/25	01:11	30.18	36.0389	-120.5939	4.37	30.23	36.0388	-120.5938	3.24	29.55	36.0168	-120.6156	6.43
258	21131275	0.94	2000/10/25	01:15	42.94	36.0452	-120.5953	5.07	42.89	36.0480	-120.5878	5.43	42.98	36.0329	-120.6064	2.29
259	21131294	1.03	2000/10/25	03:29	55.53	36.0392	-120.5938	4.52	55.54	36.0413	-120.5880	3.93	55.40	36.0284	-120.6030	0.69
260	21131302	1.23	2000/10/25	05:19	9.44	36.0409	-120.5954	4.66	9.46	36.0425	-120.5915	4.20	9.15	36.0323	-120.6015	2.32
261	21131454	1.22	2000/10/26	01:52	34.99	36.0425	-120.5979	4.57	35.05	36.0450	-120.5942	4.26	34.53	36.0371	-120.5980	3.73
262	21131891	1.33	2000/10/30	11:16	34.23	36.0142	-120.5710	4.67	34.25	36.0158	-120.5707	5.05	33.87	36.0059	-120.5825	4.98
263	21132134	0.94	2000/11/01	16:58	30.38	36.0499	-120.6045	4.64	30.42	36.0507	-120.6033	4.13	30.26	36.0179	-120.6450	5.56
264	21132388	1.15	2000/11/03	03:48	13.04	36.0394	-120.5943	4.60	13.02	36.0427	-120.5920	4.36	12.91	36.0300	-120.5945	0.92
265	21132480	1.27	2000/11/03	20:53	22.91	36.2311	-120.7942	7.50	23.00	36.2258	-120.8002	7.69	23.05	36.2209	-120.8057	5.96
266	21185642	0.00	2000/11/04	13:80	8.29	36.0575	-120.6135	6.60	8.31	36.0585	-120.6117	6.35	7.89	36.0488	-120.6160	6.17
267	21132677	1.22	2000/11/05	05:50	43.55	36.0378	-120.5923	4.73	43.54	36.0403	-120.5873	4.41	43.40	36.0281	-120.6006	1.97
268	21132681	1.31	2000/11/05	07:10	28.39	36.0228	-120.5807	4.64	28.38	36.0250	-120.5788	4.52	28.18	36.0165	-120.5900	2.42
269	21132931	1.19	2000/11/06	17:24	3.16	36.0001	-120.5617	3.34	3.17	36.0010	-120.5610	4.48	2.80	35.9916	-120.5726	4.26
270	21133032	1.41	2000/11/07	10:50	26.49	36.2709	-120.8426	5.95	26.45	36.2767	-120.8347	7.65	26.59	36.2751	-120.8386	4.90
271	21185679	1.09	2000/11/08	06:13	47.58	35.9706	-120.5207	3.94	47.56	35.9717	-120.5183	4.18	47.31	35.9627	-120.5384	0.91
272	21133867	1.34	2000/11/12	20:37	16.28	36.2712	-120.8426	5.95	16.37	36.2682	-120.8353	7.40	15.97	36.2951	-120.8229	8.81
273	21185698	0.97	2000/11/14	01:29	53.79	36.0990	-120.6659	9.35	53.93	36.0973	-120.6632	8.00	53.47	36.0892	-120.6718	8.82
274	21185701	1.09	2000/11/14	17:70	57.77	36.0091	-120.5651	6.15	57.67	36.0082	-120.5702	7.22	57.44	35.9967	-120.5878	6.59
275	21134222	1.45	2000/11/15	18:41	47.74	36.2320	-120.7957	8.45	47.79	36.2255	-120.8043	8.57	47.66	36.2221	-120.8042	7.84
276	21134493	1.54	2000/11/17	14:18	57.53	36.0355	-120.5994	1.99	57.52	36.0405	-120.5913	3.18	56.82	36.0292	-120.6099	0.26
277	21134495	1.36	2000/11/17	14:47	19.93	36.0350	-120.5996	1.85	19.91	36.0383	-120.5948	2.23	19.45	36.0294	-120.5976	0.64
278	30222381	1.67	2000/11/18	18:43	32.05	36.0596	-120.6086	10.03	32.02	36.0628	-120.6042	10.19	32.51	36.0312	-120.6323	4.26
279	21134692	1.16	2000/11/18	19:54	43.94	36.0596	-120.6081	10.04	43.93	36.0573	-120.6110	10.39	44.05	36.0379	-120.6293	6.44
280	21187360	0.00	2000/11/19	00:21	28.25	36.0608	-120.6120	9.43	28.41	36.0605	-120.6113	8.40	28.32	36.0481	-120.6208	7.95
281	21134813	1.49	2000/11/19	10:23	12.23	35.8448	-120.3919	6.61	12.16	35.8425	-120.3908	6.85	12.06	35.8438	-120.3964	5.88
282	21134838	0.94	2000/11/19	13:80	16.64	36.0483	-120.6116	1.96	16.44	36.0618	-120.6158	3.90	15.66	36.0731	-120.6790	2.46
283	21134960	1.45	2000/11/20	05:54	5.95	35.9425	-120.4882	10.28	6.09	35.9417	-120.4875	10.40	6.34	35.9309	-120.5100	7.66
284	21134962	1.27	2000/11/20	05:57	35.04	35.9426	-120.4883	10.25	35.05	35.9417	-120.4853	9.60	35.03	35.9309	-120.5114	8.56
285	21134966	2.12	2000/11/20	06:27	40.35	35.9420	-120.4877	10.30	40.35	35.9412	-120.4882	10.36	40.59	35.9320	-120.5082	7.46
286	21135411	1.88	2000/11/23	00:20	19.64	36.2807	-120.7932	3.99	19.33	36.2963	-120.7943	5.40	20.15	36.2508	-120.8095	4.14
287	21135479	1.27	2000/11/23	17:28	27.81	36.1027	-120.6591	7.95	27.73	36.1048	-120.6557	7.66	27.04	36.0896	-120.6699	9.00
288	21187383	0.00	2000/11/23	19:13	23.34	36.0193	-120.5716	10.09	23.41	36.0198	-120.5737	10.40	23.46	36.0045	-120.5944	8.82

Appendix II Comparison of VELHYPO relocated events with results of HypoDD and HYPOINVERSE.

					hypoDD				HYPOINVERSE				VELHYPO			
S/N	Event ID	Mag	Date (yy/mm/dd)	hh:mm	Time (ss)	Lat (deg)	Long (deg)	Dept (km)	Time (ss)	Lat (deg)	Long (deg)	Dept (km)	Time (ss)	Lat (deg)	Long (deg)	Dept (km)
289	21135561	1.11	2000/11/23	23:59	9.24	36.0116	-120.5693	4.51	49.37	36.0132	-120.5680	4.88	49.03	36.0045	-120.5652	1.49
290	21135580	1.24	2000/11/24	04:20	8.98	35.8482	-120.3470	7.47	9.08	35.8772	-120.3538	7.13	9.59	35.8607	-120.4074	3.70
291	21135660	1.14	2000/11/24	15:20	8.64	35.9283	-120.4770	4.93	8.65	35.9290	-120.4758	4.82	7.96	35.9237	-120.4905	4.74
292	21135730	1.69	2000/11/24	22:20	8.24	36.1487	-120.7248	3.34	48.26	36.1453	-120.7293	4.16	47.33	36.1346	-120.7371	6.99
293	21136045	2.01	2000/11/26	10:60	9.95	36.2795	-120.8538	5.57	0.06	36.2720	-120.8627	6.71	0.00	36.2768	-120.8634	5.51
294	21136128	1.19	2000/11/26	22:41	8.46	35.8716	-120.3100	11.01	8.37	35.8673	-120.3167	10.84	8.59	35.8671	-120.3343	9.22
295	21136526	2.00	2000/11/30	01:58	5.29	35.9288	-120.4779	4.91	15.36	35.9273	-120.4768	5.17	15.01	35.9233	-120.4897	4.62
296	21136531	1.73	2000/11/30	03:70	0.57	36.2410	-120.8016	5.93	50.67	36.2327	-120.8123	6.53	50.73	36.2401	-120.8043	4.55
297	21136537	1.02	2000/11/30	06:14	8.78	35.8217	-120.3692	5.19	58.66	35.8215	-120.3683	5.27	58.77	35.8245	-120.3703	3.92
298	21136545	2.95	2000/11/30	14:80	4.18	35.9062	-120.4501	6.05	4.12	35.9055	-120.4488	6.22	3.99	35.9057	-120.4579	4.37
299	21136673	1.11	2000/12/01	11:11	8.98	36.0069	-120.5627	5.49	38.97	36.0075	-120.5615	5.98	38.76	35.9965	-120.5744	5.04
300	21136677	1.29	2000/12/01	11:36	8.60	35.9621	-120.5105	10.91	28.63	35.9620	-120.5098	10.84	28.82	35.9527	-120.5293	7.58
301	21136851	1.30	2000/12/02	14:48	4.34	36.2404	-120.8007	5.81	24.37	36.2417	-120.7972	6.33	24.47	36.2436	-120.7984	4.89
302	21137017	2.32	2000/12/03	13:42	3.08	35.8571	-120.3982	4.71	3.06	35.8552	-120.3975	5.02	3.00	35.8563	-120.4038	3.35
303	21137500	1.51	2000/12/06	10:40	0.26	36.0103	-120.5720	3.06	10.25	36.0115	-120.5702	4.29	10.01	36.0026	-120.5832	2.50
304	21137763	2.91	2000/12/07	15:37	6.06	36.2432	-120.8031	6.02	26.04	36.2420	-120.8027	6.76	26.18	36.2399	-120.8125	4.50
305	21137773	1.29	2000/12/07	17:16	6.93	36.2439	-120.8043	5.86	46.90	36.2452	-120.7995	6.63	46.89	36.2415	-120.8073	5.76
306	21137924	1.13	2000/12/08	15:47	8.69	36.2089	-120.7757	5.87	38.72	36.2015	-120.7883	6.14	38.89	36.1940	-120.7896	3.37
307	21137975	1.29	2000/12/08	22:13	4.44	36.2416	-120.8021	6.07	34.54	36.2342	-120.8130	7.44	34.67	36.2217	-120.8060	9.00
308	21137977	1.30	2000/12/08	22:29	1.64	36.2416	-120.8014	5.99	41.63	36.2430	-120.8000	6.60	41.80	36.2403	-120.8031	4.83
309	21137985	1.76	2000/12/08	23:52	6.87	36.0857	-120.6475	3.26	56.88	36.0843	-120.6490	3.32	56.43	36.0690	-120.6662	4.24
310	21138067	1.32	2000/12/09	13:37	6.00	36.2306	-120.7941	5.07	35.94	36.2308	-120.7968	5.14	36.09	36.2288	-120.7945	2.92
311	21138168	1.10	2000/12/10	07:59	3.43	36.0094	-120.5708	2.63	3.45	36.0113	-120.5685	3.75	3.08	36.0021	-120.5755	3.29
312	21138434	1.42	2000/12/11	20:27	5.85	35.8024	-120.3545	9.69	55.88	35.8027	-120.3533	9.64	55.93	35.8052	-120.3552	8.99
313	21138724	1.34	2000/12/13	11:43	9.95	35.8707	-120.3112	11.25	29.81	35.8738	-120.3037	12.09	29.45	35.8836	-120.3054	12.60
314	21138815	1.29	2000/12/14	03:46	6.81	36.0066	-120.5626	5.49	56.80	36.0070	-120.5630	5.79	56.21	35.9966	-120.5773	5.61
315	21138912	1.49	2000/12/15	02:14	6.35	36.2244	-120.7870	5.09	56.37	36.2190	-120.7960	6.78	56.22	36.2179	-120.7982	8.81
316	21138933	1.34	2000/12/15	10:24	5.75	36.2243	-120.7868	5.14	15.87	36.2195	-120.7957	7.59	15.90	36.2161	-120.7962	5.30
317	21139096	1.25	2000/12/16	21:21	0.90	36.2429	-120.8029	6.10	20.94	36.2450	-120.7995	6.65	21.09	36.2427	-120.8047	5.20
318	21139147	1.23	2000/12/17	03:90	2.77	36.2714	-120.8400	7.22	22.73	36.2733	-120.8387	8.58	22.91	36.2688	-120.8416	5.36
319	21139180	1.34	2000/12/17	17:60	2.03	36.0529	-120.6072	4.35	12.02	36.0562	-120.6015	4.39	11.53	36.0437	-120.6113	3.29
320	21139420	1.10	2000/12/19	03:60	0.54	36.0064	-120.5653	4.23	0.58	36.0065	-120.5645	4.73	0.39	35.9979	-120.5704	2.83
321	21139519	2.31	2000/12/19	14:58	0.92	36.2404	-120.8049	9.03	40.98	36.2402	-120.8033	9.76	40.83	36.2378	-120.8169	9.21
322	21139645	1.03	2000/12/20	04:43	8.48	36.0334	-120.5886	4.98	58.49	36.0355	-120.5848	4.42	58.29	36.0255	-120.5976	2.56
323	30222463	1.53	2000/12/21	03:45	1.79	36.2427	-120.8035	6.12	51.84	36.2387	-120.8120	6.48	51.80	36.2391	-120.8153	5.14
324	21139926	1.33	2000/12/21	04:18	6.91	36.2433	-120.8040	6.08	56.99	36.2362	-120.8128	6.63	56.82	36.2395	-120.8064	5.79
325	21140088	1.02	2000/12/21	17:24	5.56	36.0324	-120.5885	4.69	45.57	36.0345	-120.5853	4.36	45.30	36.0240	-120.5960	3.01
326	21140267	2.73	2000/12/22	23:58	0.02	36.0804	-120.6322	4.74	0.16	36.0772	-120.6375	5.05	-0.18	36.0665	-120.6509	4.33
327	21140448	1.52	2000/12/24	00:35	7.20	36.1031	-120.6770	3.05	37.25	36.1038	-120.6765	3.25	36.53	36.0940	-120.6842	5.17
328	21140547	1.15	2000/12/24	16:16	3.88	35.9836	-120.5416	2.46	33.92	35.9827	-120.5417	4.32	33.59	35.9764	-120.5506	0.69
329	21140714	1.82	2000/12/25	20:47	8.13	36.2220	-120.7865	8.74	58.26	36.2180	-120.7958	8.46	58.27	36.2175	-120.7952	7.11
330	21140776	1.31	2000/12/26	08:14	1.50	36.0388	-120.5935	4.79	51.45	36.0423	-120.5868	4.76	51.23	36.0296	-120.6033	0.90
331	21141259	1.31	2000/12/29	03:52	8.90	35.9243	-120.4715	5.61	28.88	35.9257	-120.4687	5.73	28.39	35.9218	-120.4837	5.74
332	21141444	1.43	2000/12/30	07:51	2.10	35.9602	-120.5083	10.91	22.06	35.9602	-120.5082	10.97	22.26	35.9476	-120.5288	8.00
333	21141944	1.32	2000/12/31	06:10	9.84	36.2508	-120.8149	5.26	39.95	36.2520	-120.8143	6.86	40.12	36.2475	-120.8165	4.06