Text Supplement for ScholarWorks@UA collection "Seismic moment tensor catalog for southern Alaska"

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Description of files

The files here are part of the PhD thesis work by Vipul Silwal. This supplement will be cited in a manuscript to be submitted.

A seismic moment tensor catalog of 106 events was generated using body waves and surface waves. The best solution (M_0) was obtained through a grid-search in the double-couple moment tensor space ($\mathbb{M}$) using the "cut-and-paste" (CAP) approach of *Zhu and Helmberger* (1996). The waveform fits for the 21 events in the Part I catalog is shown in Figure A, with the best-fitting depth plots in Figure B. The uncertainty analysis for these Part I events is shown in Figure C. The waveform fits for the other 85 events (Part II) is shown in Figure D; for these events the best depth search and uncertainty analysis was not performed.

Figure A: Waveform fits (Part I catalog events) [`PartI_inv.pdf`]

Waveform fits for 21 moment tensor inversions for which detailed uncertainty analysis is peformed (Figure C). Black are observed waveforms; red are synthetic waveforms computed using a frequency-wavenumber method (*Zhao and Helmberger*, 1994) with the 1D model `scak` (*Matumoto and Page*, 1964; *Lahr*, 1975). The waveforms are fit separately within five time windows: P wave vertical component (PV), P wave radial component (PR), Rayleigh wave vertical component (Surf V), Rayleigh wave horizontal component (Surf R), and Love wave transverse component (Surf T). At far left in each row is the station name, source-station distance in km, and station azimuth in degrees. Below each pair of waveforms are four numbers: the cross-correlation time shift between data and synthetics, the cross-correlation value, the percent of the misfit function represented by the waveform pair, and the amplitude ratio between waveforms, $\ln(A_{\rm obs}/A_{\rm syn})$, where A is the max value of the waveform within the time window.

The beachball represents the best solution (i.e., the global minimum of the misfit function). The surroundng black dots denote the azimuthal location of the stations used, and the red crosses denote the lower hemisphere piercing points of the ray paths to the stations. Description of header lines:

1. `Event 20070911234634153 Model and Depth scak_094`
   The event ID is derived from the origin time of 2007-09-11 23:46:34.153). The 1D model used is `scak`, and the event depth is 94 km.

2. `FM 80 40 80 Mw 4.40 ISO 0 CLVD 0 rms 6.053e-07 VR 44.0`
   The moment tensor solution is strike 80°, dip 40°, rake 80° (same as the beachball). The ISOtropic and the CLVD is 0 for all events because of the double couple assumption used in this study.

3. `Filter periods (seconds): Body:1.50-4.00. Surf:16.00-40.00`
   The body waves were filtered 1.5–4.0 s, the surface waves were filtered 16–40 s.

4. `# norm L1 # Pwin 15 Swin 120 # N 37 Np 71 Ns 74`
   An L1 norm was used for the misfit function. The (reference) P-window is 15 s long, the surface wave window is 120 s long, there are 37 stations with at least one waveform, 71 is the number of P windows used, and 74 is the number of surface wave windows used.

Figure B: Depth plots (Part I catalog events) [`PartI_dep.pdf`]

Best-fitting depth grid search for 21 events (Part I). The depth increment for the grid search is 2 km. The red arrow marks the Alaska Earthquake Center catalog depth, and the white arrow marks the depth obtained from the moment tensor inversion. The long tick marks on the x-axis mark the layer boundaries in the 1D model `scak` (*Matumoto and Page*, 1964; *Lahr*, 1975) used in the moment tensor inversions. The plot shows the variance reduction (gray curve) with scale on the right. On the left is the variance reduction relative to the minimum variance reduction. The depth uncertainty is calculated based on the depth at which the variance reduction is 0.10 worse than at the best solution. Note that the earthquake magnitude is free to change for each depth, and it generally increases with increasing depth for the best-fitting solution, as we might expect.

Figure C: Uncertainty analysis plot (Part I catalog events) [`PartI_unc.pdf`]

Uncertainty analysis for 21 events (Part I). See Figure A for the corresponding waveform fits. The set $\mathbb{M}$ of moment tensors under consideration is the set of double couples. The moment tensor solution M_0 is chosen as the reference moment tensor for analysis. (a) Beachball for M_0. The big black dots are the P-T axes of M_0, and the small red and blue dots are the P-T axes of 200 tensors of the posterior distribution. (b) A two-dimensional summary of the three-dimensional plot of misfit in (i). The blue region consists of all pairs of ($\omega(M)$, $\Phi(M)$), where $M \in \mathbb{M}$, Φ is the misfit function and $\omega(M) = \angle(M_0, M)$ is the angular distance from M_0 to M. The green dots are pairs ($\omega(M)$, $\Phi(M)$) for 200 posterior samples. (c) The curve $P'(\omega)$ is the posterior probability density, and $V'(\omega)$ is homogeneous probability density for all samples in $\mathbb{M}$. These curves are the derivatives of the curves in (d). (d) The curves $V(\omega)$ and $P(\omega)$ are the cumulative measures of $V'(\omega)$ and $P'(\omega)$ respectively. They are used to construct the confidence curve $\mathscr{P}(\mathrm{V})$ in (e). (e) The confidence curve $\mathscr{P}(\mathrm{V})$ for M_0. The more the curve resembles the shape of a captial gamma (Γ), the better. The shaded area is the average confidence $\mathscr{P}_{\mathrm{AV}}$. (f) Map showing the earthquake source and the station coverage. (g) 20 moment tensor samples of the posterior distribution. The number above each beachball M is its angular distance $\omega(M)$ from M_0, and the color of the ball gives its relative misfit, using the same color scale as in (i). (h) Strike, rake, and dip distribution for a set of 2,000 posterior samples. There are two possible fault normal and slip vector pairs for a double couple; green indicates the pair having its coordinates in the strike-dip-rake box in (i), and black indicates its conjugate. (i) Colored map of misfit, $\Phi(M)$, shown on sections of strike-dip-rake space that pass through the strike-dip-rake point for M_0 (white star). The black curves are contours of ω, not contours of misfit.

Figure D: Waveform fits (Part II catalog events) [PartII_inv.pdf]

Waveform fits for rest of the 85 events. See Figure A for caption. But here we also use some first-motion polarity observations to contrain the moment tensor search space. At far left in each row is the station name, source-station distance in km, station azimuth in degrees, and the first-motion polarity info (if used).

Text file table for moment tensor catalog [SCAK_mech.txt]

Complete seismic moment tensor catalog comprising of all 106 events (21 Part I and 85 Part II). See the header lines in the file for details.

Input text files used in the moment tensor inversion [input_weight_files.zip]

We provide a text file for each of the 106 events in this study. These files show which stations and which time windows were used (or not) in each moment tensor inversion. It also shows the first-motion polarity observations that were used.

References

Lahr, J. C. (1975), Detailed seismic investigation of Pacific-North American plate interaction in southern Alaska, *Ph. D. Thesis, Columbia University*, p. 88.

Matumoto, T., and R. A. Page (1964), Microaftershocks following the alaska earthquake of 28 march 1964: Determination of hypocenters and crustal velocities in the kenai peninsula-prince william sound area, the prince william sound, alaska, earthquake of 1964 and aftershocks, *U.S. Govt. Printing Office, Washington*, *10*(3), 157–173.

Zhao, L.-S., and D. V. Helmberger (1994), Source estimation from broadband regional seismograms, *Bull. Seis. Soc. Am.*, *84*(1), 91–104.

Zhu, L., and D. Helmberger (1996), Advancement in source estimation techniques using broadband regional seismograms, *Bull. Seis. Soc. Am.*, *86*(5), 1634–1641.