

# List of Figures

1.1	Frequency dependence of sensitivity kernels . . . . .	5
1.2	Sensitivity kernel for a crustal P wave . . . . .	6
1.3	The frequency dependence of the seismic wavefield . . . . .	7
1.4	Iterative improvement in seismic waveforms, I . . . . .	8
1.5	Iterative improvement in seismic waveforms, II . . . . .	9
1.6	Reflected Rayleigh wave at the Tehachapi Mountains . . . . .	10
2.1	Source–receiver geometry for southern California . . . . .	47
2.2	Example computation of $G_{ik}$ using rays and kernels . . . . .	48
2.3	Hessian matrix $\tilde{\mathbf{H}} = \mathbf{G}^T \mathbf{G}$ . . . . .	49
2.4	Model recovery and damping in classical tomography . . . . .	50
2.5	Formation of an event kernel for a single receiver . . . . .	51
2.6	Construction of an adjoint source function . . . . .	52
2.7	Experimental setup for data and synthetics . . . . .	53
2.8	Formation of an event kernel for multiple receivers . . . . .	54
2.9	Construction of a misfit kernel . . . . .	55
2.10	Smoothing the misfit kernel . . . . .	56
2.11	Conjugate gradient algorithm, Part 1 . . . . .	57
2.12	Conjugate gradient algorithm, Part 2 . . . . .	59
2.13	Recovery of a Rayleigh wave phase-speed model . . . . .	60
2.14	Effect of the number of events . . . . .	61
2.15	Effect of the degree of smoothing and scalelength of heterogeneity . . . . .	62
2.16	Source recovery for unperturbed wave-speed structure . . . . .	63
2.17	Joint inversion for source and structural parameters . . . . .	64
2.18	Source recovery during a joint inversion . . . . .	65

2.19	Mapping source errors onto structure and vice versa . . . . .	66
2.20	Misfit comparison of classical and adjoint tomography . . . . .	67
3.1	Sketch of 2D model setup and ray paths . . . . .	72
3.2	SH seismograms . . . . .	73
3.3	SH <sub>S</sub> sequence of $\mathbf{s}\text{-}\mathbf{s}^\dagger$ interaction . . . . .	74
3.4	SH <sub>S</sub> sequence of $\mathbf{s}\text{-}\mathbf{s}^\dagger$ interaction . . . . .	75
3.5	Reversing different time windows of the SH wavefield . . . . .	76
3.6	Six SH kernels for reversing S . . . . .	77
3.7	P-SV seismograms . . . . .	78
3.8	P-SV <sub>PS+SP</sub> sequence of $\mathbf{s}\text{-}\mathbf{s}^\dagger$ interaction . . . . .	79
3.9	P-SV <sub>PS+SP</sub> sequence of $\mathbf{s}\text{-}\mathbf{s}^\dagger$ interaction . . . . .	80
3.10	Nine P-SV kernels for reversing PS+SP . . . . .	81
3.11	Reversing different time windows of P-SV . . . . .	82
4.1	Initial and target source and structure for subspace experiments . . . . .	91
4.2	Structure inversion using source subspace method . . . . .	92
4.3	Source inversion using source subspace method . . . . .	93
5.1	Example seismogram for windowing algorithm, I . . . . .	104
5.2	Example seismogram for windowing algorithm, II . . . . .	105
5.3	Example of window selection results for southern California, I . . . . .	106
5.4	Example of window selection results for southern California, II . . . . .	107
5.5	Example of window selection results for southern California, III . . . . .	108
5.6	Example of window selection results for southern California, IV . . . . .	109
6.1	Southern California topography and bathymetry . . . . .	139
6.2	Earthquake sources and stations . . . . .	141
6.3	Iterative seismogram fit . . . . .	142
6.4	Vertical cross sections and seismograms . . . . .	143
6.5	Horizontal cross sections of $V_S$ tomographic models . . . . .	145
6.6	Horizontal cross sections of $V_B$ tomographic models . . . . .	146
6.7	Seismogram fits for selected paths in the final model . . . . .	147
6.8	Waveform misfit analysis . . . . .	151

6.9	Traveltime misfit analysis . . . . .	152
6.10	Coverage for the $V_S$ tomographic model . . . . .	153
6.11	Coverage for the $V_B$ tomographic model . . . . .	154
C.1	The measurement convention . . . . .	191
D.1	Source mechanisms: 1 through 8 out of 294 . . . . .	197
D.2	Source mechanisms: 9 through 16 out of 294 . . . . .	198
D.3	Source mechanisms: 17 through 24 out of 294 . . . . .	199
D.4	Source mechanisms: 25 through 32 out of 294 . . . . .	200
D.5	Source mechanisms: 33 through 40 out of 294 . . . . .	201
D.6	Source mechanisms: 41 through 48 out of 294 . . . . .	202
D.7	Source mechanisms: 49 through 56 out of 294 . . . . .	203
D.8	Source mechanisms: 57 through 64 out of 294 . . . . .	204
D.9	Source mechanisms: 65 through 72 out of 294 . . . . .	205
D.10	Source mechanisms: 73 through 80 out of 294 . . . . .	206
D.11	Source mechanisms: 81 through 88 out of 294 . . . . .	207
D.12	Source mechanisms: 89 through 96 out of 294 . . . . .	208
D.13	Source mechanisms: 97 through 104 out of 294 . . . . .	209
D.14	Source mechanisms: 105 through 112 out of 294 . . . . .	210
D.15	Source mechanisms: 113 through 120 out of 294 . . . . .	211
D.16	Source mechanisms: 121 through 128 out of 294 . . . . .	212
D.17	Source mechanisms: 129 through 136 out of 294 . . . . .	213
D.18	Source mechanisms: 137 through 144 out of 294 . . . . .	214
D.19	Source mechanisms: 145 through 152 out of 294 . . . . .	215
D.20	Source mechanisms: 153 through 160 out of 294 . . . . .	216
D.21	Source mechanisms: 161 through 168 out of 294 . . . . .	217
D.22	Source mechanisms: 169 through 176 out of 294 . . . . .	218
D.23	Source mechanisms: 177 through 184 out of 294 . . . . .	219
D.24	Source mechanisms: 185 through 192 out of 294 . . . . .	220
D.25	Source mechanisms: 193 through 200 out of 294 . . . . .	221
D.26	Source mechanisms: 201 through 208 out of 294 . . . . .	222
D.27	Source mechanisms: 209 through 216 out of 294 . . . . .	223

D.28 Source mechanisms: 217 through 224 out of 294 . . . . .	224
D.29 Source mechanisms: 225 through 232 out of 294 . . . . .	225
D.30 Source mechanisms: 233 through 240 out of 294 . . . . .	226
D.31 Source mechanisms: 241 through 248 out of 294 . . . . .	227
D.32 Source mechanisms: 249 through 256 out of 294 . . . . .	228
D.33 Source mechanisms: 257 through 264 out of 294 . . . . .	229
D.34 Source mechanisms: 265 through 272 out of 294 . . . . .	230
D.35 Source mechanisms: 273 through 280 out of 294 . . . . .	231
D.36 Source mechanisms: 281 through 288 out of 294 . . . . .	232
D.37 Source mechanisms: 289 through 294 out of 294 . . . . .	233
E.1 Polarity problem for station CRP.CI, I . . . . .	243
E.2 Polarity problem for station CRP.CI, II . . . . .	244
E.3 Polarity problem for station HWB.AZ, I . . . . .	245
E.4 Polarity problem for station HWB.AZ, II . . . . .	246
E.5 Polarity problem for station BVDA2.AZ, I . . . . .	247
E.6 Polarity problem for station BVDA2.AZ, II . . . . .	248
E.7 Polarity problem for station PER.CI, I . . . . .	249
E.8 Polarity problem for station PER.CI, II . . . . .	250
E.9 Polarity problem for station PER.CI, III . . . . .	251
E.10 Polarity problem for station BTP.CI, I . . . . .	252
E.11 Polarity problem for station BTP.CI, II . . . . .	253
E.12 Polarity problem for station BTP.CI, III . . . . .	254
E.13 Polarity problem for station NSS2.CI, I . . . . .	255
E.14 Polarity problem for station NSS2.CI, II . . . . .	256
E.15 Polarity problem for station NSS2.CI, III . . . . .	257
E.16 Polarity problem for station 109C.TA, I . . . . .	258
E.17 Polarity problem for station 109C.TA, II . . . . .	259
E.18 Polarity problem for station 109C.TA, III . . . . .	260
E.19 Polarity problem for station OSI.CI, I . . . . .	261
E.20 Polarity problem for station OSI.CI, II . . . . .	262
E.21 Polarity problem for station OSI.CI, III . . . . .	263

E.22 Polarity problem for station OSI.CI, IV . . . . .	264
E.23 Amplification problem for station VCS.CI, I . . . . .	265
E.24 Amplification problem for station VCS.CI, II . . . . .	266
E.25 Amplification problem for station VCS.CI, III . . . . .	267
E.26 Amplification problem for station SMTC.AZ, I . . . . .	268
E.27 Amplification problem for station SMTC.AZ, II . . . . .	269
E.28 Amplification problem for station BAR.CI, I . . . . .	270
E.29 Amplification problem for station BAR.CI, II . . . . .	271