

Index

- β Cepheids, 161
- A/D converter, 91, 246
- absorption band, 86, 244
- adjoint inversion, 4, 302
- Akaike's information criterion, 266
- aliasing, 247
- amplitude
 - defined as rms, 144
 - peak-to-peak, 143
- Andoyer–Lambert approximation, 237
- anisotropy, 284
 - and crystal symmetry, 286
 - apparent, 286
 - azimuthal, 285, 296
 - birefringence, 284
 - flow, 34
 - Fréchet kernel, 297
 - hexagonal symmetry, 288
 - lattice-preferred orientation (LPO), 284, 286
 - Pn-waves, 284
 - radial, 285, 288
 - S-wave splitting, 284, 291
 - shape-preferred orientation (SPO), 286
 - surface waves, 296, 298
 - tradeoff with heterogeneity, 285
 - transverse, 285
 - Voigt matrix, 286
 - xenoliths, 295
- anti-leakage operator, 214
- arrival times, *see* phase picks
- associated Legendre function, 157
 - asymptotic expression, 175
- astroseismology, 161, 307
- attenuation
 - and focusing, 142, 153
 - asthenosphere, 104, 142, 245
 - dispersion correction, 244
 - effect on body wave spectra, 101
 - Fréchet kernel, 153
 - frequency dependence, 86
 - intrinsic, 79
 - mechanisms, 81
 - normal modes, 155
 - standing wave, 82
- azimuth, 52, 178
 - deviation, 205
 - sign convention, 52
- background model, 10, 113, 254
- backprojection, 1, 257
 - check on data misfit, 281
 - in adjoint inversion, 304
 - in LSQR, 268
- Backus–Gilbert theory, 2, 275
 - resolving length, 277
 - translation invariance for Sun, 279
 - variance of the average, 277
- banana-doughnut kernel, *see* Fréchet kernel
- Bayes' theorem, 261
- Bayesian inference, 4, 260
 - subjective constraints, 261
 - unit resolution matrix, 274
 - versus damping, 271
- bias
 - from damping, 259, 260, 275
 - in IASP91 and AK135, 238
 - in resolution matrix, 272
 - neglected in error, 261
- bootstrapping, 281
- Born theory, 8, 68, 124
 - for phase velocity maps, 212
 - amplitude healing, 148
 - anisotropy, 293
 - neglect of energy loss, 60, 61
 - surface waves, 204
 - validity, 131, 134, 205, 301
- boundary topography, 149
- bulk modulus, 16
- canonical form, 20
- caustics, 25, 127, 134, 140
- centroid parameters, 241
- chi square (χ^2), 250
 - acceptable values, 252
 - data subsets, 253

- reduced, 252
- Clairbout's conjecture, 7
- Clairaut's equation, 229
- clustering, 102, 242
- colatitude, 40
- conditional probability density, 269
- convolution, 37
- CoRoT satellite, 247
- coordinates
 - Cartesian, 11
 - polar, 22
 - ray-centred, 47
 - spherical, 17
- CoRoT satellite, 307
- correction
 - as unknown parameter, 249
 - bathymetry, 232
 - clock errors, 247
 - crust, 235
 - dispersion, 244
 - ellipticity, 228, 237
 - for t^* , 104
 - hypocentre, 238
 - instrument response, 245
 - origin time, 238
 - scalar moment, 244
 - station amplitude, 243
 - topography, 232, 238
- correlator performance estimate (CPE), 99
- correspondence principle, 83
- counts, 247
- covariance matrix, 256, 261, 269
 - Monte Carlo estimate, 281
- Cowling approximation, 158
- Cramér–Rao lower bound, 99, 117
- cross validation, 211
- cross-correlation, 99
 - attenuation correction, 244
 - differential travel times, 103
 - of doublets, 104
 - of noise, 108
 - of P and PP, 105
 - perturbation theory, 120
 - surface waves, 210
 - zero sensitivity on ray, 124
- cross-validation, 281
- CRUST2.0, 236
- data errors
 - propagation in inversion, 281
- decibel (dB), 82, 91
- Delauney mesh, 219
- delay times, *see* phase picks
 - corrections, 228
 - definition, 95
 - evolution, 114
 - finite-frequency, 113
 - outliers, 251
- delta function, 35
- density perturbation
 - effect on amplitude, 130, 142
 - effect on delay time, 119
 - effect on eigenfrequencies, 155
 - effect on eigenfrequency, 163
- detour time, 123
- digitization noise, 90
- Dijkstra's algorithm, 42
- Dirac comb, 90
- dot-product test, 267
- double couple source, 63, 179
- double difference tomography, 104
- dynamic range, 91
- EarthScope, 306
- eigenfrequency, 155
 - degenerate, 158
 - perturbation theory, 163
- eigenfunctions, 158
 - normalization, discrete modes, 160
 - normalization, surface waves, 179
- eikonal equation, 20
 - finite-difference scheme, 45
 - Hamilton-Jacobi form, 46
- elasticity tensor, 14, 285
 - anelastic, 84
 - symmetries, 14, 286
 - transversely isotropic, 289
- elastodynamic equations, 12, 15
 - anisotropy, 290
 - operator notation, 68
 - spherical coordinates, 156
- ellip.f, 231
- energy flux, 66
- ENO algorithms, 46
- epicentral distance, 22, 41
- error propagation
 - and damping, 260
 - Monte Carlo test, 281
- excitation factor
 - body waves, 62
 - normal modes, 172
 - surface waves, 178
- fast marching method, 46
- Fermat's principle, 27, 113, 230
- finite-frequency delay, 115, 134
- finite-frequency kernel, *see* Fréchet kernel
- floats, 306
- flow velocities, 33, 112
- Fourier Transform, 35
 - sign conventions, 16
- Fourier transform
 - sign conventions, 77
- Fréchet kernel, 124
 - acoustic waves, 132
 - azimuthal anisotropy, 297
 - body wave Q , 153
 - body wave amplitudes, 148
 - body wave delays, 129
 - boundary topography, 149
 - by mode summation, 135
 - P-wave delay, 124

- picked maxima, 133
- robust cross-correlation estimates, 132
- S-wave splitting, 294
- singularities, 140, 224
- surface wave Q , 208
- surface wave amplitude, 207
- surface wave phase, 207
- Fresnel zone, 30

- gain ranging, 92
- Gaussian distribution, 250
 - deviations from, 251, 281
- Gaussian probability, 261
- generalized data functionals, 306
- generalized inverse, 271
- geometrical spreading, 25, 66
 - reciprocity, 67
 - Riccati equation, 81
 - surface waves, 179
- ghosts, 97, 145
- Global Seismic Network (GSN), 91, 106, 247
- GMT, 219
- GOLF, 160
- gravity
 - Cowling approximation, 158
 - neglect of, 13
- gravity modes (g modes), 160
- gravity waves, 161
- great circle, 204
- Green's function, 31
 - acoustic, 58
 - elastic, 61
 - far field, 64
 - ray approximation, 67
- Green's tensor, 68
- grid optimization, 221
- group arrival time, 111, 114
- group velocity, 176, 177, 197
 - higher modes, 188
 - maps, 186
 - measurement, 186
- Hamiltonian, 49
- Heaviside function, 65
- Heaviside step function, 36
- helioseismology
 - dispersion, 161, 181
 - Dopplergram, 105, 107
 - flow, 33
 - history, 7
 - mode types, 160
 - space missions, 307
 - time–distance analysis, 107, 109, 111
 - topographic correction, 232
- Helmholtz potentials, 61
- Hermitian operators, 162
- Hilbert transform, 105, 127
- Huygens' principle, 29
- hydrophone, 15, 305
- hypothesis testing, 282

- image smoothing, 223

- imoment rate function, *see* source time function
- impedance, 62
 - effect on amplitude, 142, 242
- impulse response, 59, 77
- incompressibility, 16
 - attenuation, 84
- information theory, 263
- instrument response
 - accuracy, 247
- interaction coefficient
 - azimuthal anisotropy, 297
 - body waves, 129
 - boundary depth, 238
 - SKS, 294
 - surface waves, 205
- interferometry, seismic, 88, 108
- interpolation
 - B-spline, 218
 - in tetrahedra, 218, 219
 - Lagrange, 217
 - Newton, 41
 - plotting artefacts, 223
- ISC catalogue, 241, 253, 266
- ISC delay times, 2, 3, 93, 238
 - clock errors, 248
 - source depth interpretation, 233
- isotropy, 10
 - attenuation, 84
 - ray theory, 25

- jackknifing, 281
- joint probability density, 269

- Kepler mission, 307
- Kronecker delta δ_{ij} , 15

- L-22 geophone, 247
- Lagrange multipliers, 264, 303
- Lamé parameters λ, μ , 25
- Las Cumbres network, 307
- latitude
 - geocentric, 232
 - geographic, 232
- leaking, 279
- leap second, 248
- least squares, 251, 252
 - and iterative reweighting, 254
 - damped systems, 259
 - for Backus–Gilbert analysis, 278
 - underdetermined systems, 255
- likelihood function, 94, 251, 262
- Love waves, 180
 - love.f, 181
 - radial anisotropy, 288
- Love–Rayleigh discrepancy, 285
- LSQR, 267

- marginal probability density, 269
- Maslov index, 127
- matched filter, 97
- matrix computation, 223

- maximum likelihood estimate, 250
- Mie scattering, 56
- MINEOS, 160
- minimax phase, 118
- minimum norm solution, 256
 - bias, 272
- model covariance
 - priori, 261, 273, 275
- model variance
 - posteriori, 259
- modelling errors, 250
- modes, 155
 - coupling by Coriolis force, 165
 - gravity, 161
 - higher, 183
 - receiver strip, 173
 - software, 160
 - solar (p-,f-,g-modes), 160
 - spheroidal, 160
 - splitting, 165
 - summation and causality, 175
 - toroidal, 160
- mollifying, *see* Backus–Gilbert theory
- moment tensor, 63
- multiplet, 158
 - splitting function, 199
 - coupling, 166
 - fitting shape, 169
 - stripping, 172
- NACT approximation, 202
- near-field terms, 62, 294
- nearest neighbours, 221, 263
- NEIC, 95, 233, 241
- noise, *see also* data errors
 - and matched filter, 100
 - and station bias, 96
 - average power, 36
 - cross-correlation function (NCF), 108
 - digitization, 90
 - in GSN stations, 106
 - influence on phase pick, 134
 - microseismic, 91, 107
 - white, 98
- normal equations, *see* least squares
- nullspace shuttle, 283
- Nyquist frequency, 90
- Occam's razor, 265
- ocean acoustics, 3
 - flow, 33
 - Fréchet kernels, 132
- ocean islands, 237
- outliers, 248, 251, 254, 281
- parametrization
 - global, 215
 - local, 217
- paraxial rays, 48
 - breakdown near antipode, 140
- Parseval's theorem, 36
- partial derivatives
 - eigenfrequency, 164
 - group velocity, 186
 - phase velocity, 183
 - wavenumber, 189
- partitioned waveform inversion (PWI), 191
 - starting model, 193
 - uncorrelated error estimate, 192
- path average approximation (PAVA), 202
- phase picks, 90, 93
 - accuracy, 94, 95
 - autoregressive model, 94
 - bias, 96
 - by cross-correlation, 99
 - from maxima, 133
 - non-Gaussian errors, 251
 - Wielandt effect, 115
- phase velocity, 180
 - and depth of wave, 183
- phase velocity maps, 185
 - incompatible with finite-frequency, 212
- plane wave, 18, 60
 - scattering, 70
- point scatterer, 60
- polar phase shift, 206
- polarization, 27
 - of scattered waves, 74, 119
- qP and qS-waves, 291
- receiver, 179, 206
- S-wave splitting, 284
- scattered wave, 294
- SKS-wave, 293
- surface waves, 180, 285
- SV and SH, 72
- polarization factor, 63
- poles and zeroes, 246
- post sweeping, 47
- power density spectrum, 37
- power spectrum, 35
 - Gaussian, 139
- pressure, 15
 - radiation, 160
 - volume change, 16
 - zero at surface, 31
- probability, 269
- probability density, 269
- propagator matrix, 137
- Q, *see* attenuation
 - discrete mode, 162
 - intrinsic, 83, 208
 - scattering, 88
 - standing wave, 82
 - surface wave, 179
 - travelling wave, 82, 179
- qhull, 219
- quality factor, *see* Q
- quantum numbers, 160
- radial correlation function, 226
- radiation pattern, 67, 126, 145

- radiative transfer theory, 302
- random packing, 221
- ray bending, 42
- ray parameter, 21
- ray theory, 10
 - interpretation of delays, 113
 - surface waves, 185
 - validity
 - amplitudes, 143
 - and anomaly size, 115
 - and ray length, 57, 115
 - Fresnel zone, 57
 - PWI, 194
- ray tracing, 39
 - dynamic, 48, 135
 - in 3D media, 45
 - on the sphere, 51
- ray-Born inversion, 9, 305
- raydytrace.f, 231
- Rayleigh scattering, 56, 88
- Rayleigh waves, 180
 - radial anisotropy, 288
 - rayleigh.f, 181
- Rayleigh's principle, 163, 183
- reciprocity
 - amplitude, 67
 - correlations, 108
 - time, 31
- reciprocity test, 44
- refraction seismology, 132
- regularization
 - and Bayesian inference, 261
 - and bias, 260
 - and convergence, 263
 - and metaphysics, 264
 - and model parametrization, 218
 - and subjective damping, 274
 - and unwanted scaling, 267
 - effect of resolution matrix, 273
 - resolution test, 279
 - Tikhonov, 259
- residue theorem, 77
- resolution matrix, 272
 - and Backus–Gilbert theory, 277
 - and prior constraints, 273
 - bias, 274
 - for Bayesian estimate, 274
 - for damped solution, 273
- reverberations
 - and crustal corrections, 237
 - effect on amplitude, 243
 - in water layer, 243
- rheology, 86
- Riccati equation, 50
- ridge regression, 260
- rotation matrix, 54
- row-action algorithms, 267
- Runge-Kutta method, 40
- Rytov approximation, 131
- S-wave splitting, 291
 - Fréchet kernel, 294
- SAC, 247
- scalar moment, 63
- scattering
 - angle, 71, 206
 - forward, 56, 121
 - isotropic, 61
 - multiple, 68
 - single, *see* Born theory
- scattering matrix, 74
- SDO, 307
- sediment layer, 242
- SEED format, 247
- selection rules, 169
- sensitivity test, 4, 279
 - dominant wavelength, 279
 - versus resolution analysis, 280
- shooting, 39
- shortest path method, 42
- SIAMOUS, 307
- signal-to-noise ratio (SNR)
 - and data scrambling, 281
 - and matched filter, 98
 - broadband sensors, 116
 - P delays, 96
 - refraction seismology, 132
- singular value decomposition (SVD), 255
 - truncated, 258
- slowness
 - relation to wavenumber, 182
 - spherical Earth, 22
 - vector, 20
- smearing, 279
- Snel's law, 21
- software repository, xiii
- SOHO, 7, 160
- Solar Orbiter mission, 307
- SONG, 307
- source propagation, 102
- source time function, 100
- spectral element method, 135
- spherical harmonics Y_{ℓ}^m , 3, 157
 - addition theorem, 200
 - horizontal resolution, 216
 - model parametrization, 169, 215
 - orthogonality, 158
 - spectral analysis, 224
- splitting intensity, 292
- splitting matrix, 166
 - estimation, 168, 171
 - relation to heterogeneity, 169
- step function, 36
- strain tensor, 14
- stress tensor, 10
 - symmetry, 15
- STS-1 seismometer, 247
- subevents, 95
- summary rays, 95, 96
 - outliers, 248
 - variance, 96, 266
- Sun, *see* helioseismology

- surface waves
 - connection with body waves, 182
- traction, 10
- travel time, *see* phase picks
 - baseline problem, 94
 - definition, 93
 - differential, 104, 240
 - Sun, 111
 - variance, 96
 - vertical, 235
- tstar (t^*), 146
- undertones, 161
- univariant data, 251
- Universal Time (UTC), 247
- US Array, 306
- variance reduction, 254
- velocity
 - acoustic, 16
 - change with time, 104
 - complex, 85
 - frequency dependence, 87
 - group, 203
 - intrinsic, 16
 - P and S, 27
 - phase, 176, 180
- Voronoi polyhedron, 220
- water layer, 233
- wave
 - acoustic, 15, 149
 - P and S, 27
 - polarization, 27
 - qP and qS, 291
 - surface, 175
- wave parameter, 57
- wavefront healing, 57
 - amplitudes, 148
 - and anomaly size, 115
 - diffusion equation, 143
 - slow/fast anomaly, 115
- wavelength, 17
- wavelet
 - pulse estimate, 100
 - Ricker, 133
- wavelet decomposition, 221, 265
- wavenumber
 - angular, 17
 - Fourier transform, 77
 - horizontal, 182
 - imaginary component, 85
 - measurement techniques, 188
 - perturbations, 183, 189
 - relation to angular order, 196
 - relation to phase velocity, 180
 - ring-diagram analysis, 187
 - surface wave, 180
 - vector, 17
- Wielandt effect, 116
- Wiener–Khinchine theorem, 37
- Wigner 3j symbols, 169
- windowing, 208
 - cosine taper, 210
 - effect on body wave amplitudes, 145, 147, 243
 - effect on Fréchet kernel, 130, 211
 - multitaper, 210
 - operator, 190
- WKBJ algorithm, 101
- WWSSN, 2, 90
 - instrument response, 245