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Seismic Wave Theory - Edward S. Krebes 2019-03-28
Concise textbook on seismic wave theory, with detailed derivations of formulas, clear explanations of topics, exercises, and selected answers.

Seismic Migration Using the Wave Equation - A. J. Berkhout 1978

Transient Waves in Visco-Elastic Media - Norman Ricker 2012-12-02
Developments in Solid Earth Geophysics 10: Transient Waves in Visco-Elastic Media deals with the propagation of transient elastic

disturbances in visco-elastic media. More specifically, it explores the visco-elastic behavior of a medium, whether gaseous, liquid, or solid, for very-small-amplitude disturbances. This volume provides a historical overview of the theory of the propagation of elastic waves in solid bodies, along with seismic prospecting and the nature of seismograms. It also discusses the seismic experiments, the behavior of waves propagated in accordance with the Stokes wave equation, and wavelet functions and their polynomials. The book explains the laws of propagation of seismic wavelets and seismic ray paths, as well as the equations of wavelet propagation, the velocity-type seismic wavelet, and the spectrum of the wavelet. It discusses the motion of a mechanical seismograph disturbed by extraneous forces or motions. It also provides information on the differential equation describing the motion of a galvanometer, laboratory studies of wavelet contraction, and characteristics of a wavelet-contractor amplifier. Furthermore, the book explains the experimental studies of the primary seismic disturbance and internal friction. This monograph is a valuable source of information for physicists, students who want to pursue a career in geophysics or selenophysics, and those who actively working in these fields.

Theory of Seismic Imaging - John A. Scales 1995-05-17

Seismic imaging methods are currently used to produce images of the Earth's subsurface properties at diverse length scales, from high-resolution, near-surface environmental studies for oil and gas exploration to long-period images of the entire planet. This book presents the physical and mathematical basis of imaging algorithms in the context of controlled-source reflection seismology. The approach taken is motivated by physical optics and theoretical seismology. The theory is constantly put into practice via a graded sequence of computer exercises using the widely available SU (Seismic Unix) software package.

Introduction to Seismology - Peter M. Shearer 2009-06-11

This book provides an approachable and concise introduction to seismic theory, designed as a first course for undergraduate students. It clearly explains the fundamental concepts, emphasizing intuitive understanding over lengthy derivations. Incorporating over 30% new material, this second edition includes all the topics needed for a one-semester course in seismology. Additional material has been added throughout including numerical methods, 3-D ray tracing, earthquake location, attenuation, normal modes, and receiver functions. The chapter on earthquakes and source theory has been extensively revised and enlarged, and now includes details on non-double-couple sources, earthquake scaling, radiated energy, and finite slip inversions. Each chapter includes worked problems and detailed exercises that give students the opportunity to apply the techniques they have learned to compute results of interest and to illustrate the Earth's seismic properties. Computer subroutines and datasets for use in the exercises are available at www.cambridge.org/shearer.

Elastic Waves in the Earth - Walter L. Pilant 2012-12-02

Elastic Waves in the Earth provides information on the relationship between seismology and geophysics and their general aspects. The book offers elastodynamic equations and derivative equations that can be used in the propagation of elastic waves. It also covers major topics in detail, such as the fundamentals of elastodynamics; the Lamb's problem, which includes the Cagniard-de Hoop theory; rays and modes in a radially inhomogeneous earth and in multilayered media, which includes the Thomson-Haskell theory; the elastic wave dissipation; the seismic source and noise; and the seismographs. The book consists of 33 chapters. The first 16 chapters include basic material related to the propagation of elastic waves. Topics covered by these chapters include scalars, vectors, and tensors in cartesian coordinates, stress and strain analysis, equations of elasticity and motion, plane waves, Rayleigh waves, plane-wave theory, and fluid-fluid and solid-solid interfaces. The second half of the book covers various ray and mode theories, elastic wave dissipation, and the observations and theories of seismic source and seismic noise. It concludes by discussing earthquake seismology and different seismographs, like the pendulum seismometer and the strain seismometer.

Reflection Seismology - Yang Wencai
2013-09-18

Authored by a geophysicist with more than 50 years of experience in research and instruction, Reflection Seismology: Theory, Data Processing and Interpretation provides a single source of foundational knowledge in reflection seismology principles and theory. Reflection seismology has a broad range of applications and is used primarily by the oil and gas industry to provide high-resolution maps and build a coherent geological story from maps of processed seismic reflections. Combined with seismic attribute analysis and other exploration geophysics tools, it aids geologists and geo-engineers in creating geological models of areas of exploration and extraction interest. Yet as important as reflection seismology is to the hydrocarbon industry, it’s difficult to find a single source that synthesizes the topic without having to wade through numerous journal articles from a range of different publishers. This book is a one-stop source of reflection seismology theory, helping scientists navigates through the wealth of new data processing techniques that have emerged in recent years. Provides geoscientists and geo-engineers with a theoretical framework for navigating the rapid emergence of new data processing techniques Presents a single source of reflection seismology content instead of a scattering of disparate journal articles Features more than 100 figures, illustrations, and working examples to aid the reader in retaining key concepts Arms geophysicists and geo-engineers with a solid foundation in seismic wave equation analysis and interpretation

Seismic Wave Propagation in Non-Homogeneous Elastic Media by Boundary Elements - George D. Manolis 2016-09-23

This book focuses on the mathematical potential and computational efficiency of the Boundary Element Method (BEM) for modeling seismic wave propagation in either continuous or discrete inhomogeneous elastic/viscoelastic, isotropic/anisotropic media containing multiple cavities, cracks, inclusions and surface topography. BEM models may take into account the entire seismic wave path from the seismic source through the geological deposits all the way up to the local site under consideration. The general presentation of the theoretical basis of elastodynamics for inhomogeneous and heterogeneous continua in the first part is followed by the analytical derivation of fundamental solutions and Green's functions for the governing field equations by the usage of Fourier and Radon transforms. The numerical implementation of the BEM is for antiplane in the second part as well as for plane strain boundary value problems in the third part. Verification studies and parametric analysis appear throughout the book, as do both recent references and seminal ones from the past. Since the background of the authors is in solid mechanics and mathematical physics, the presented BEM formulations are valid for many areas such as civil engineering, geophysics, material science and all others concerning elastic wave propagation through inhomogeneous and heterogeneous media. The material presented in this book is suitable for self-study. The book is written at a level suitable for advanced undergraduates or beginning graduate students in solid mechanics, computational mechanics and fracture mechanics.

Waves and Rays in Elastic Continua - Michael A Slawinski 2014-12-15

The present book — which is the third, significantly revised edition of the textbook originally published by Elsevier Science — emphasizes the interdependence of mathematical formulation and physical meaning in the description of seismic phenomena. Herein, we use aspects of continuum mechanics, wave theory and ray theory to explain phenomena resulting from the propagation of seismic waves. The book is divided into three main sections: Elastic Continua, Waves and Rays and Variational Formulation of Rays. There is also a fourth part, which consists of appendices. In Elastic Continua, we use continuum mechanics to describe the material through which seismic waves propagate, and to formulate a system of equations to study the behaviour of such a material. In Waves and Rays, we use these equations to identify the types of body waves propagating in elastic continua as

well as to express their velocities and displacements in terms of the properties of these continua. To solve the equations of motion in anisotropic inhomogeneous continua, we invoke the concept of a ray. In Variational Formulation of Rays, we show that, in elastic continua, a ray is tantamount to a trajectory along which a seismic signal propagates in accordance with the variational principle of stationary traveltime. Consequently, many seismic problems in elastic continua can be conveniently formulated and solved using the calculus of variations. In the Appendices, we describe two mathematical concepts that are used in the book; namely, homogeneity of a function and Legendre's transformation. This section also contains a list of symbols.
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Seismic Modeling and Imaging with the Complete Wave Equation - Ralph Phillip Bording 1997

Seismic modelling and imaging of the earth's subsurface are complex and difficult computational tasks. The authors of this volume present general numerical methods based on the complete wave equation for solving these important seismic exploration problems.

Seismic Wave Propagation and Scattering in the Heterogenous Earth - Haruo Sato 2008-12-17

Seismic waves – generated both by natural earthquakes and by man-made sources – have produced an enormous amount of information about the Earth's interior. In classical seismology, the Earth is modeled as a sequence of uniform horizontal layers (or sperical shells) having different elastic properties and one determines these properties from travel times and dispersion of seismic waves. The Earth, however, is not made of horizontally uniform layers, and classic seismic methods can take large-scale inhomogeneities into account. Smaller-scale irregularities, on the other hand, require other methods. Observations of continuous wave trains that follow classic direct S waves, known as coda waves, have shown that there are heterogeneities of random size scattered randomly throughout the layers of the classic seismic model. This book focuses on recent developments in the area of seismic wave propagation and scattering through the randomly heterogeneous structure of the Earth, with emphasis on the lithosphere. The presentation combines information from many sources to present a coherent introduction to the theory of scattering in acoustic and elastic materials and includes analyses of observations using the theoretical methods developed.

Seismic Waves and Sources - A. Ben-Menahem 2012-12-06

Earthquakes come and go as they please, leaving behind them trails of destruc tion and casualties. Although their occurrence is little affected by what we do or think, it is the task of earth scientists to keep studying them from all possible angles until ways and means are found to divert, forecast, and eventually control them. In ancient times people were awestruck by singular geophysical events, which were attributed to supernatural powers. It was recognized only in 1760 that earthquakes originated within the earth. A hundred years later, first systematic attempts were made to apply physical principles to study them. During the next century scientists accumulated knowledge about the effects of earthquakes, their geographic patterns, the waves emitted by them, and the internal constitution of the earth. During the past 20 years, seismology has made a tremendous progress, mainly because of the advent of modern computers and improvements in data acquisi tion systems, which are now capable of digital and analog recording of ground motion over a frequency range of five orders of magnitude. These technologic developments have enabled seismologists to make measurements with far greater precision and sophistication than was previously possible. Advanced computational analyses have been applied to high-quality data and elaborate theoretical models have been devised to interpret them. As a result, far reaching advances in our knowledge of the earth's structure and the nature of earthquake sources have occurred.

Elastic Wave Field Extrapolation - C.P.A. Wapenaar 2014-04-14

Extrapolation of seismic waves from the earth's surface to any level in the subsurface plays an essential role in many advanced seismic processing schemes, such as migration, inverse scattering and redatuming. At present these schemes are based on the acoustic wave equation. This means not only that S-waves (shear waves) are ignored, but also that P-waves (compressional waves) are not handled correctly. In the seismic industry there is an important trend towards multi-component data acquisition. For processing of multi-component seismic data, ignoring S-waves can no longer be justified. Wave field extrapolation should therefore be based on the full elastic wave equation. In this book the authors review acoustic one-way extrapolation of P-waves and introduce elastic one-way extrapolation of P- and S-waves. They demonstrate that elastic extrapolation of multi-component data, decomposed into P- and S-waves, is essentially equivalent to acoustic extrapolation of P-waves. This has the important practical consequence that elastic processing of multi-component seismic data need not be significantly more complicated than acoustic processing of single-component seismic data. This is demonstrated in the final chapters, which deal with the application of wave field extrapolation in the redatuming process of single- and multi-component seismic data. Geophysicists, and anyone who is interested in a review of acoustic and elastic wave theory, will find this book useful. It is also a suitable textbook for graduate students and those following courses in elastic wave field extrapolation as each subject is introduced in a relatively simple manner using the scalar acoustic wave equation. In the chapters on elastic wave field extrapolation the formulation, whenever possible, is analogous to that used in the chapters on acoustic wave field extrapolation. The text is illustrated throughout and a bibliography and keyword index are provided.

Wave Equation Synthesis and Inversion of Diffracted Multiple Seismic Reflections - Don Clinton Riley 1974

Applied Seismic Wave Theory - A. J. Berkhout 1987

An Introduction to G-type Seismic Waves - DINESH HALDER

In this book we study of the propagation of G type waves along the plane surface at the interface of two different types of media. The upper medium is taken as monoclinic magneto-elastic layer whereas the lower half space is inhomogeneous isotropic. Keeping terms up to first order, the Laplace transform of the displacement is obtained. Dispersion equation and condition for maximum energy flow near the surface are obtained in compact form. The dispersion equation is in assertion with the classical Love-type wave equation for the isotropic case. Effect of magnetic field and inhomogeneity on phase velocity and variation of group velocity with scaled wave number has been depicted by means of graphs. It is observed that inhomogeneity decreases phase velocity and the magnetic field has the favoring effect. A comparative study for the case of isotropic layer and monoclinic layer over the same isotropic inhomogeneous half space has been made through graphs

Numerical Modeling of Seismic Wave Propagation - Johan O. A. Robertsson 2012

The decades following SEG's 1990 volume on numerical modeling showed a step change in the application and use of full wave equation modeling methods enabled by the increase in computational power. Full waveform inversion, reverse time migration, and 3D elastic finite-difference synthetic data generation are examples. A searchable CD is included.

Digital Imaging and Deconvolution - Enders A. Robinson 2008

Covering ideas and methods while concentrating on fundamentals, this book includes wave motion; digital imaging; digital filtering; visualization aspects of the seismic reflection method; sampling theory; the frequency spectrum; synthetic seismograms; wavelet processing; deconvolution; seismic attributes; phase rotation; and seismic attenuation.

The Earth’s Free Oscillations - Oleg V. Petrov 2021-01-29

This book presents the formulations and solutions of the wave equation for the Earth’s free oscillations concerning the particular nodal, bifurcation, perspectival, and projective reference points within the framework of the three “great geometries” of Euclid, Lobachevsky, and Riemann. When studying the relationship between the propagation velocity of various types of bulk and surface seismic waves with radial, spheroidal, and torsional eigen oscillations of the Earth having corresponding periods, we are struck by the fundamental problem of obtaining reference points that allow physical meaning to be attributed to all these discrete oscillatory and continuous wave phenomena that occur in nature. Several unsuccessful attempts tried to unify the relationship of discrete oscillations and the velocity of waves and light occurring in seismology and other phenomena associated with gravity and matter, using a three-dimensional visual space-time model continuous Euclidean space. Using simple and illustrative examples for describing the free oscillations of the Earth and taking into account new visible event horizons related to the velocity of waves and light propagation, the author formulated and solved the fundamental wave equation of nature in the form of the three “great theorems”: Galilean, Lorentz, and Poincaré spatiotemporal transformations.

Fundamentals of Seismic Wave Propagation - Chris Chapman 2004-07-29

Fundamentals of Seismic Wave Propagation, published in 2004, presents a comprehensive introduction to the propagation of high-frequency body-waves in elastodynamics. The theory of seismic wave propagation in acoustic, elastic and anisotropic media is developed to allow seismic waves to be modelled in complex, realistic three-dimensional Earth models. This book provides a consistent and thorough development of modelling methods widely used in elastic wave propagation ranging from the whole Earth, through regional and crustal seismology, exploration seismics to borehole seismics, sonics and ultrasonics. Particular emphasis is placed on developing a consistent notation and approach throughout, which highlights similarities and allows more complicated methods and extensions to be developed without difficulty. This book is intended as a text for graduate courses in theoretical seismology, and as a reference for all academic and industrial seismologists using numerical modelling methods. Exercises and suggestions for further reading are included in each chapter.

Full-3D Seismic Waveform Inversion - Po Chen 2015-09-10

This book introduces a methodology for solving the seismic inverse problem using purely numerical solutions built on 3D wave equations and which is free of the approximations or simplifications that are common in classical seismic inversion methodologies and therefore applicable to arbitrary 3D geological media and seismic source models. Source codes provided allow readers to experiment with the calculations demonstrated and also explore their own applications.

Seismic Wave Propagation in the Earth - A. Hanyga 2016-07-29

This volume contains an extensive presentation of the theory, phenomenology and interpretation of seismic waves produced by natural and artificial sources. Each theoretical topic discussed in the book is presented in a self-contained and mathematically rigorous form, yet without excessive demands on the reader's mathematical background. It is the only book to include such a complete presentation of the mathematical background and modern developments of the WKBJ theory of seismic waves, and detailed discussions of its wide ranging applications. The book will therefore be useful to postgraduate students and research workers specialising in seismic wave theory, theoretical seismology, electromagnetic wave theory and other fields of wave propagation theory.

A Stable Finite Difference Method for the Elastic Wave Equation on Complex Geometries with Free Surfaces - 2007

The isotropic elastic wave equation governs the propagation of seismic waves caused by earthquakes and other seismic events. It also governs the propagation of waves in solid material structures and devices, such as gas pipes, wave guides, railroad rails and disc brakes. In the vast majority of wave propagation problems arising in seismology and solid mechanics there are free surfaces. These free surfaces have, in general, complicated shapes and are rarely flat. Another feature, characterizing problems arising in these areas, is the strong heterogeneity of the media, in which the problems are posed. For example, on the characteristic length scales of seismological problems, the geological structures of the earth can be considered piecewise constant, leading to models where the values of the elastic properties are also piecewise constant. Large spatial contrasts are also found in solid mechanics devices composed of different materials welded together. The presence of curved free surfaces, together with the typical strong material heterogeneity, makes the design of stable, efficient and accurate numerical methods for the elastic wave equation challenging. Today, many different classes of numerical methods are used for the simulation of elastic waves. Early on, most of the methods were based on finite difference approximations of space and time derivatives of the equations in second order differential form (displacement formulation), see for example [1, 2]. The main problem with these early discretizations were their inability to approximate free surface boundary conditions in a stable and fully explicit manner, see e.g. [10, 11, 18, 20]. The instabilities of these early methods were especially bad for problems with materials with high ratios between the P-wave (C{sub p}) and S-wave (C{sub s}) velocities. For rectangular domains, a stable and explicit discretization of the free surface boundary conditions is presented in the paper [17] by Nilsson et al. In summary, they introduce a discretization, that use boundary-modified difference operators for the mixed derivatives in the governing equations. Nilsson et al. show that the method is second order accurate for problems with smoothly varying material properties and stable under standard CFL constraints, for arbitrarily varying material properties. In this paper we generalize the results of Nilsson et al. to curvilinear coordinate systems, allowing for simulations on non-rectangular domains. Using summation by parts techniques, we show that there exists a corresponding stable discretization of the free surface boundary condition on curvilinear grids. We also prove that the discretization is stable and energy conserving both in semi-discrete and fully discrete form. As for the Cartesian method in, [17], the stability and conservation results holds for arbitrarily varying material properties. By numerical experiments it is established that the method is second order accurate.

Scattering and Attenuation of Seismic Waves, Part II - WU 2013-11-21

Reprint from Pure and Applied Geophysics (PAGEOPH), Volume 131 (1989), No. 4

Seismic Inverse Q Filtering - Yanghua Wang 2009-01-26

Seismic inverse Q filtering is a data processing technology for enhancing the resolution of seismic images. It employs a wave propagation reversal procedure that compensates for energy absorption and corrects wavelet distortion due to velocity dispersion. By compensating for amplitude attenuation, seismic data can provide true relative-amplitude information for amplitude inversion and subsequent reservoir characterization. By correcting the phase distortion, seismic data with enhanced vertical resolution can yield correct timings for lithological identification. This monograph presents the theory of inverse Q filtering and a series of algorithms, collected with the following selection criteria in mind: robustness, effectiveness and practicality. The book is written for processing geophysicists who are attempting to improve the quality of seismic data in terms of resolution and signal-to-noise ratio, as well as for reservoir geophysicists who are concerned about seismic fidelity in terms of true amplitudes, true timings and true frequencies. It will also be particularly valuable as a guide for seasoned geophysicists who are attempting to develop seismic software for various research settings. Finally, it can be used as a reference work or textbook for postgraduate students in seismic and reservoir geophysics.

Basic Geophysics - Enders A. Robinson 2017-09-01

For a thorough comprehension of the field of geophysics, we need to understand its origins. Basic Geophysics by Enders Robinson and Dean Clark takes us on a journey that demonstrates how the achievements of our predecessors have paved the way for our modern science. From the ancient Greeks through the Enlightenment to the greats of the contemporary age, the reasoning behind basic principles is explored and clarified. With that foundation, several advanced topics are examined, including: the 3D wave equation; ray tracing and seismic modeling; reflection, refraction, and diffraction; and WKBJ migration. The successful integration of the historical narrative alongside practical analysis of relevant principles makes this book an excellent resource for both novices and professionals, and all readers will gain insight and appreciation for the seismic theory that underlies modern exploration seismology.

The Earth's Free Oscillations - Oleg V. Petrov 2021

This book presents the formulations and solutions of the wave equation for the Earth's free oscillations concerning the particular nodal, bifurcation, perspectival, and projective reference points within the framework of the three "great geometries" of Euclid, Lobachevsky, and Riemann. When studying the relationship between the propagation velocity of various types of bulk and surface seismic waves with radial, spheroidal, and torsional eigen oscillations of the Earth having corresponding periods, we are struck by the fundamental problem of obtaining reference points that allow physical meaning to be attributed to all these discrete oscillatory and continuous wave phenomena that occur in nature. Several unsuccessful attempts tried to unify the relationship of discrete oscillations and the velocity of waves and light occurring in seismology and other phenomena associated with gravity and matter, using a three-dimensional visual space-time model continuous Euclidean space. Using simple and illustrative examples for describing the free oscillations of the Earth and taking into account new visible event horizons related to the velocity of waves and light propagation, the author formulated and solved the fundamental wave equation of nature in the form of the three "great theorems": Galilean, Lorentz, and Poincaré spatiotemporal transformations.

Numerical Modeling of Seismic Wave Propagation - K. R. Kelly 1990

Seismic Wave Propagation - J. E. White 2000

Exploration Seismology - R. E. Sheriff 1995-08-25

This is the completely updated revision of the highly regarded book Exploration Seismology. Available now in one volume, this textbook provides a complete and systematic discussion of exploration seismology. The first part of the book looks at the history of exploration seismology and the theory - developed from the first principles of physics. All aspects of seismic acquisition are then described. The second part of the book goes on to discuss data-processing and interpretation. Applications of seismic exploration to groundwater, environmental and reservoir geophysics are also included. The book is designed to give a comprehensive up-to-date picture of the applications of seismology. Exploration Seismology's comprehensiveness makes it suitable as a text for undergraduate courses for geologists, geophysicists and engineers, as well as a guide and reference work for practising professionals.

Seismic Wave Propagation in Stratified Media - Brian Kennett 2009-05-01

Seismic Wave Propagation in Stratified Media presents a systematic treatment of the interaction of seismic waves with Earth structure. The theoretical development is physically based and is closely tied to the nature of the seismograms observed across a wide range of distance scales - from a few kilometres as in shallow reflection work for geophysical prospecting, to many thousands of kilometres for major earthquakes. A unified framework is presented for all classes of seismic phenomena, for both body waves and surface waves. Since its first publication in 1983 this book has been an important resource for understanding the way in which seismic waves can be understood in terms of reflection and transmission properties of Earth models, and how complete theoretical seismograms can be calculated. The methods allow the development of specific approximations that allow concentration on different seismic arrivals and hence provide a direct tie to seismic observations.

Full Seismic Waveform Modelling and Inversion - Andreas Fichtner 2010-11-16

Recent progress in numerical methods and computer science allows us today to simulate the propagation of seismic waves through realistically heterogeneous Earth models with unprecedented accuracy. Full waveform tomography is a tomographic technique that takes advantage of numerical solutions of the elastic wave equation. The accuracy of the numerical solutions and the exploitation of complete waveform information result in tomographic images that are both more realistic and better resolved. This book develops and describes state of the art methodologies covering all aspects of full waveform tomography including methods for the numerical solution of the elastic wave equation, the adjoint method, the design of objective functionals and optimisation schemes. It provides a variety of case studies on all scales from local to global based on a large number of examples involving real data. It is a comprehensive reference on full waveform tomography for advanced students, researchers and professionals.

Computational Seismology - Heiner Igel 2017

An introductory text to a range of numerical methods used today to simulate time-dependent processes in Earth science, physics, engineering and many other fields. It looks under the hood of current simulation technology and provides guidelines on what to look out for when carrying out sophisticated simulation tasks.

Seismic Inversion - Gerard T. Schuster 2017-07-01

This book describes the theory and practice of inverting seismic data for the subsurface rock properties of the earth. The primary application is for inverting reflection and/or transmission data from engineering or exploration surveys, but the methods described also can be used for earthquake studies. Seismic Inversion will be of benefit to scientists and advanced students in engineering, earth sciences, and physics. It is desirable that the reader has some familiarity with certain aspects of numerical computation, such as finite-difference solutions to partial differential equations, numerical linear algebra, and the basic physics of wave propagation. For those not familiar with the terminology and methods of seismic exploration, a brief introduction is provided. To truly understand the nuances of seismic inversion, we have to actively practice what we preach (or teach). Therefore, computational labs are provided for most of the chapters, and some field data labs are given as well.

Scattering and Attenuation of Seismic Waves - Keiiti Aki 1989

Seismic Waves and Rays in Elastic Media - M.A. Slawinski 2003-08-04

This book seeks to explore seismic phenomena in elastic media and emphasizes the interdependence of mathematical formulation and physical meaning. The purpose of this title - which is intended for senior undergraduate and graduate students as well as scientists interested in quantitative seismology - is to use aspects of continuum mechanics, wave theory and ray theory to describe phenomena resulting from the propagation of waves. The book is divided into three parts: Elastic continua, Waves and rays, and Variational formulation of rays. In Part I, continuum mechanics are used to describe the material through which seismic waves propagate, and to formulate a system of equations to study the behaviour of such material. In Part II, these equations are used to identify the types of body waves propagating in elastic continua as well as to express their velocities and displacements in terms of the properties of these continua. To solve the equations of motion in anisotropic inhomogeneous continua, the high-frequency approximation is used and establishes the concept of a ray. In Part III, it is shown that in elastic continua a ray is tantamount to a trajectory along which a seismic signal propagates in accordance with the variational principle of stationary travel time.

Handbook of Deep Learning Applications - Valentina Emilia Balas 2019-02-25

This book presents a broad range of deep-learning applications related to vision, natural language processing, gene expression, arbitrary object recognition, driverless cars, semantic image segmentation, deep visual residual abstraction, brain–computer interfaces, big data processing, hierarchical deep learning networks as game-playing artefacts using regret matching, and building GPU-accelerated deep learning frameworks. Deep learning, an advanced level of machine learning technique that combines class of learning algorithms with the use of many layers of nonlinear units, has gained considerable attention in recent times. Unlike other books on the market, this volume addresses the challenges of deep learning implementation, computation time, and the complexity of reasoning and modeling different type of data. As such, it is a valuable and comprehensive resource for engineers, researchers, graduate students and Ph.D. scholars.

Seismic Wave Propagation and Scattering in the Heterogeneous Earth : Second Edition - Haruo Sato 2012-01-28

Seismic waves - generated both by natural earthquakes and by man-made sources - have produced an enormous amount of information about the Earth's interior. In classical seismology, the Earth is modeled as a sequence of uniform horizontal layers (or spherical shells) having different elastic properties and one determines these properties from travel times and dispersion of seismic waves. The Earth, however, is not made of horizontally uniform layers, and classic seismic methods can take large-scale inhomogeneities into account. Smaller-scale irregularities, on the other hand, require other methods. Observations of continuous wave trains that follow classic direct S waves, known as coda waves, have shown that there are heterogeneities of random size scattered randomly throughout the layers of the classic seismic model. This book focuses on recent developments in the area of seismic wave propagation and scattering through the randomly heterogeneous structure of the Earth, with emphasis on the lithosphere. The presentation combines information from many sources to present a coherent introduction to the theory of scattering in acoustic and elastic materials and includes analyses of observations using the theoretical methods developed. The second edition especially includes new observational facts such as the spatial variation of medium inhomogeneities and the temporal change in scattering characteristics and recent theoretical developments in the envelope synthesis in random media for the last ten years. Mathematics is thoroughly rewritten for improving the readability. Written for advanced undergraduates or beginning graduate students of geophysics or planetary sciences, this book should also be of interest to civil engineers, seismologists, acoustical engineers, and others interested in wave propagation through inhomogeneous elastic media.

Computationally Efficient Methods for Uncertainty Quantification in Seismic Inversion - Georgia K. Stuart 2020

Full waveform inversion is an iterative optimization technique used to estimate subsurface physical parameters in the earth. A seismic energy source is generated in a borehole or on the surface of the earth which causes a seismic wave to propagate into the underground material. The transmitted wave then reflects off of material interfaces (rocks and fluids) and the returning wave is recorded at geophones. The inverse problem involves estimating parameters that describe this wave propagation (such as velocity) to minimize the misfit between the measured data and data we simulate from our mathematical model. The seismic velocity inversion problem is difficult because it contains sources of uncertainty, due to the instruments used to record the data and our mathematical model for seismic wave propagation. Using uncertainty quantification (UQ), we construct distributions of earth velocity models. Distributions give information about how probable an Earth model is, given the recorded seismic data. This rich information impacts real-world decision making, such as where to drill a well to produce oil and gas. UQ methods based on repeated sampling to construct estimates of the distribution, such as Markov chain Monte Carlo (MCMC), are desirable because they do not impose restrictions on the shape of the distribution. How ever, MCMC methods are computationally expensive because they require solving the wave equation repeatedly to generate simulated seismic wave data. This dissertation focuses on techniques to reduce the computational expense of MCMC methods for the seismic velocity inversion problem. Two-stage MCMC uses an inexpensive filter to cheaply reject unacceptable velocity models. The operator upscaling method, an inexpensive surrogate for the wave equation, is one such filter. We find that two-stage MCMC with the operator upscaling filter is effective at producing the same uncertainty information as traditional one-stage MCMC, but reduces the computational cost by between 20% and 45%. A neural network, in conjunction with operator upscaling, is another choice of filter. We find that the neural network filter reduces the computational cost of MCMC by 65% for our experiment, which includes the time needed to generate the training set and the neural network. The size of the problem we can solve using two-stage MCMC is limited by the random walk sampler. Hamiltonian Monte Carlo (HMC) and the No-U-Turn sampler (NUTS) use gradient information and Hamiltonian dynamics to steer the sampler, thereby eliminating the inefficient random walk behavior. Discretizing Hamiltonian dynamics requires two user specified parameters: trajectory length and step size. The NUTS algorithm avoids setting the trajectory length in advance by constructing variable-length paths. We find that the NUTS algorithm for seismic inversion results in superior decrease in the residual over traditional HMC while removing the need for costly tuning runs. However, constructing the gradient for the seismic inverse problem is computationally expensive. In two-stage, neural network-enhanced HMC we replace the costly gradient computation with a neural network. Additionally, we use the neural network to reject unacceptable samples as in two-stage MCMC. We find that the two-stage neural network HMC scheme reduces the computational cost by over 80% when compared to traditional HMC for a 100-unknown layered problem.

Wave Equation Travel Time Tomography Based on the Adjoint Method - Xiaofeng Zhang 2012

Wave equation travel time Tomography based on the adjoint method is an advanced and useful theory to simulate the wave propagation and inversion. More practices and applications need to be implemented widely. A real seismic survey project is been done as an example in this paper with the above theory implementation. Also the comparison results can be funded in this paper. Wave equation travel time Tomography based on the adjoint method is also a complex, long running, and repeated process. A desire to free hand from the inversion process needs to be met. Windows Workflow Foundation in .net 4.0 provides the feasibility to implement the inversion process automatically. The visual studio 2010 provides friendly platform for users to simply drag the function activity to design all kinds of workflow which also allowed both forward and backward workflow design. The benefits of the automatic implement the wave equation travel time inversion workflow is not limited to save the operating time, but also improves the inversion efficiency by reducing the un-continued running gap between each step. Furthermore, the automatic process provides the feasibility to implement other inversion process and reduce the seismic imaging period. Wave Equation travel time tomography based on the adjoint method simulates the wave propagation path exactly in three-dimensional media which provides more accurate velocity model and much higher resolution image than the ray tracing theory which tracks the wave propagation path in two-dimensional media. That is also a big reason why the wave equation tomography is more accurate than the conventional tomography. Wave equation travel time Tomography based on adjoint method is not a new theory which was developed in 1980s but it was been limited by the requirements of large computing source which is used to calculate three-dimensional wave equations and to construct three-dimensional Fréchet kernel. Until recent years, following by the barge computing technology development, applying wave equation travel time tomography to large scale of earthquake and exploration become implementable. In the practice of wave equation travel time tomography based on the adjoint method, forward wave-field and adjoint wave-field are been calculated by using source time function instead of storing green function. For adjoint wave-field, the wave field source is been derived by using reversed time signal at receiver as simultaneous source which is based on reciprocity of the green function property. And also all the synthetic seismogram relative to one shot can be simulated simultaneously for each wave-field calculation. Three-dementional Fréchet derivative is constructed by using both forward and adjoint wave-fields. Without storing green function, large disk space could be saved. In the meanwhile the simulation of two wave-fields will double the memory required. Since Hessian is also not available in the calculation, inversion process needs to be solved iteratively.