

Introduction To Synthetic Aperture Radar Sar Pola

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Polarimetric Radar Imaging - Jong-Sen Lee 2017-12-19

The recent launches of three fully polarimetric synthetic aperture radar (PolSAR) satellites have shown that polarimetric radar imaging can provide abundant data on the Earth's environment, such as biomass and forest height estimation, snow cover mapping, glacier monitoring, and damage assessment. Written by two of the most recognized leaders in this field, *Polarimetric Radar Imaging: From Basics to Applications* presents polarimetric radar imaging and processing techniques and shows how to develop remote sensing applications using PolSAR imaging radar. The book provides a substantial and balanced introduction to the basic theory and advanced concepts of polarimetric scattering mechanisms, speckle statistics and speckle filtering, polarimetric information analysis and extraction techniques, and applications typical to radar polarimetric remote sensing. It explains the importance of wave polarization theory and the speckle phenomenon in the information retrieval problem of microwave imaging and inverse scattering. The authors demonstrate how to devise intelligent information extraction algorithms for remote sensing applications. They also describe more advanced polarimetric analysis techniques for polarimetric target decompositions, polarization orientation effects, polarimetric scattering modeling, speckle filtering, terrain and forest classification, manmade

target analysis, and PolSAR interferometry. With sample PolSAR data sets and software available for download, this self-contained, hands-on book encourages you to analyze space-borne and airborne PolSAR and polarimetric interferometric SAR (Pol-InSAR) data and then develop applications using this data.

Synthetic Aperture Radar Polarimetry - Jakob J. van Zyl 2011-10-14

This book describes the application of polarimetric synthetic aperture radar to earth remote sensing based on research at the NASA Jet Propulsion Laboratory (JPL). This book synthesizes all current research to provide practical information for both the newcomer and the expert in radar polarimetry. The text offers a concise description of the mathematical fundamentals illustrated with many examples using SAR data, with a main focus on remote sensing of the earth. The book begins with basics of synthetic aperture radar to provide the basis for understanding how polarimetric SAR images are formed and gives an introduction to the fundamentals of radar polarimetry. It goes on to discuss more advanced polarimetric concepts that allow one to infer more information about the terrain being imaged. In order to analyze data quantitatively, the signals must be calibrated carefully, which the book addresses in a chapter summarizing the basic calibration algorithms. The book concludes with examples of applying polarimetric analysis

to scattering from rough surfaces, to infer soil moisture from radar signals.

Imaging from Spaceborne and Airborne SARs, Calibration, and Applications - Masanobu Shimada 2018-10-26

Sixty years after its birth, Synthetic Aperture Radar (SAR) evolved as a key player of earth observation, and it is continually upgraded by enhanced hardware functionality and improved overall performance in response to user requirements. The basic information gained by SAR includes the backscattering coefficient of targets, their phases (the truncated distance between SAR and its targets), and their polarization dependence. The spatiotemporal combination of the multiple data operated on the satellite or aircraft significantly increases its sensitivity to detect changes on earth, including temporal variations of the planet in amplitude and the interferometric change for monitoring disasters; deformations caused by earthquakes, volcanic activity, and landslides; environmental changes; ship detection; and so on. Earth-orbiting satellites with the appropriate sensors can detect environmental changes because of their large spatial coverage and availability. Imaging from Spaceborne and Airborne SARs, Calibration, and Applications provides A-to-Z information regarding SAR researches through 15 chapters that focus on the JAXA L-band SAR, including hardware description, principles of SAR imaging, theoretical description of SAR imaging and error, ScanSAR imaging, polarimetric calibration, inflight antenna pattern, SAR geometry and ortho rectification, SAR calibration, defocusing for moving targets, large-scale SAR imaging and mosaic, interferometric SAR processing, irregularities, application, and forest estimation. Sample data are created by using L-band SAR, JERS-1, PALSAR, PALSAR-2, and Pi-SAR-L2. This book is based on the author's experience as a principal researcher at JAXA with responsibilities for L-band SAR operation and researches. It reveals the inside of SAR processing and application researches performed at JAXA, which makes this book a valuable reference for a wide range of SAR researchers, professionals, and students.

Polarimetric Synthetic Aperture Radar - Irena Hajsek 2021-03-24

This open access book focuses on the practical application of electromagnetic polarimetry principles in Earth remote sensing with an educational purpose. In the last decade, the operations from fully polarimetric synthetic aperture radar such as the Japanese ALOS/PALSAR, the Canadian Radarsat-2 and the German TerraSAR-X and their easy data access for scientific use have developed further the research and data applications at L, C and X band. As a consequence, the wider distribution of polarimetric data sets across the remote sensing community boosted activity and development in polarimetric SAR applications, also in view of future missions. Numerous experiments with real data from spaceborne platforms are shown, with the aim of giving an up-to-date and complete treatment of the unique benefits of fully polarimetric synthetic aperture radar data in five different domains: forest, agriculture, cryosphere, urban and oceans.

Government Reports Announcements & Index - 1992

IGARSS '88 - 1988

Advances in Near-surface Seismology and Ground-penetrating Radar, Volume 15 - Richard D. Miller 2010-01-11

Advances in Near-surface Seismology and Ground-penetrating Radar (SEG Geophysical Developments Series No. 15) is a collection of original papers by renowned and respected authors from around the world. Technologies used in the application of near-surface seismology and ground-penetrating radar have seen significant advances in the last several years. Both methods have benefited from new processing tools, increased computer speeds, and an expanded variety of applications. This book, divided into four sections--"Reviews," "Methodology," "Integrative Approaches," and "Case Studies"--captures the most significant cutting-edge issues in active areas of research, unveiling truly pertinent studies that address fundamental applied problems. This collection of manuscripts grew from a core group of papers presented at a post-convention workshop, "Advances in Near-surface Seismology and Ground-penetrating Radar," held during the 2009 SEG Annual Meeting in

Houston, Texas. This is the first cooperative publication effort between the near-surface communities of SEG, AGU, and EEGS. It will appeal to a large and diverse audience that includes researchers and practitioners inside and outside the near-surface geophysics community. --Publisher description.

A New Target Detector Based on Geometrical Perturbation Filters for Polarimetric Synthetic Aperture Radar (POL-SAR) - Armando Marino
2012-01-25

This thesis presents a groundbreaking methodology for the radar international community. The detection approach introduced, namely perturbation analysis, is completely novel showing a remarkable capability of thinking outside the box. Perturbation analysis is able to push forward the performance limits of current algorithms, allowing the detection of targets smaller than the resolution cell and highly embedded in clutter. The methodology itself is extraordinary flexible and has already been used in two other large projects, funded by the ESA (European Space Agency): M-POL for maritime surveillance, and DRAGON-2 for land classification with particular attention to forests. This book is a perfectly organised piece of work where every detail and perspective is taken into account in order to provide a comprehensive vision of the problems and solutions.

IGARSS. - 1988

IGARSS '99 Proceedings - 1999

Volcano Deformation - Daniel Dzurisin 2006-11-24

Volcanoes and eruptions are dramatic surface manifestations of dynamic processes within the Earth, source models over the past three decades. There has mostly but not exclusively localized along the been a virtual explosion of volcano-geodesy studies boundaries of Earth's relentlessly shifting tectonic and in the modeling and interpretation of ground plates. Anyone who has witnessed volcanic activity deformation data. Nonetheless, other than selective, has to be impressed by the variety and complexity of brief

summaries in journal articles and general visible eruptive phenomena. Equally complex, works on volcano-monitoring and hazards mitigation (e. g. , UNESCO, 1972; Agnew, 1986; Scarpa geochemical, and hydrothermal processes that occur and Tilling, 1996), a modern, comprehensive treatise on underground - commonly undetectable by the means of volcano geodesy and its applications was human senses - before, during, and after eruptions. non-existent, until now. Experience at volcanoes worldwide has shown that, In the mid-1990s, when Daniel Dzurisin (DZ to at volcanoes with adequate instrumental monitoring friends and colleagues) was serving as the Scientist in-Charge, nearly all eruptions are preceded and accompanied by measurable changes in the physical and tectonic (CVO), I first learned of his dream to write a (or) chemical state of the volcanic system. While working on volcano geodesy.

Understanding Synthetic Aperture Radar Images - Chris Oliver 2004
This practical reference shows SAR system designers and remote sensing specialists how to produce higher quality SAR images using data-driven algorithms, and apply powerful new techniques to measure and analyze SAR image content.

Radar Systems Analysis and Design Using MATLAB - Bassem R. Mahafza
2015-09-15

Developed from the author's graduate-level courses, the first edition of this book filled the need for a comprehensive, self-contained, and hands-on treatment of radar systems analysis and design. It quickly became a bestseller and was widely adopted by many professors. The second edition built on this successful format by rearranging and updating topics and code. Reorganized, expanded, and updated, *Radar Systems Analysis and Design Using MATLAB®*, Third Edition continues to help graduate students and engineers understand the many issues involved in radar systems design and analysis. Each chapter includes the mathematical and analytical coverage necessary for obtaining a solid understanding of radar theory. Additionally, MATLAB functions/programs in each chapter further enhance comprehension of

the theory and provide a source for establishing radar system design requirements. Incorporating feedback from professors and practicing engineers, the third edition of this bestselling text reflects the state of the art in the field and restructures the material to be more convenient for course use. It includes several new topics and many new end-of-chapter problems. This edition also takes advantage of the new features in the latest version of MATLAB. Updated MATLAB code is available for download on the book's CRC Press web page.

Scientific and Technical Aerospace Reports - 1987

Lists citations with abstracts for aerospace related reports obtained from world wide sources and announces documents that have recently been entered into the NASA Scientific and Technical Information Database.

Modern Technologies for Landslide Monitoring and Prediction -

Marco Scaioni 2015-01-23

Modern Technologies for Landslide Investigation and Prediction presents eleven contributed chapters from Chinese and Italian authors, as a follow-up of a bilateral workshop held in Shanghai on September 2013. Chapters are organized in three main parts: ground-based monitoring techniques (photogrammetry, terrestrial laser scanning, ground-based InSAR, infrared thermography, and GNSS networks), geophysical (passive seismic sensor networks) and geotechnical methods (SPH and SLIDE), and satellite remote-sensing techniques (InSAR and optical images). Authors of these contributes are internationally-recognized experts in their respective research fields. Marco Scaioni works in the college of Surveying and Geo-Informatics at Tongji University, Shanghai (P.R. China). His research fields are mainly Close-range Photogrammetry, Terrestrial Laser Scanning, and other ground-based sensors for metrological and deformation monitoring applications to structural engineering and geosciences. In the period 2012-2016 he is chairman of the Working Group V/3 in the International Society for Photogrammetry and Remote Sensing, focusing on 'Terrestrial 3D Imaging and Sensors'.

Earth Resources - 1977

Introduction to Microwave Remote Sensing - Iain H. Woodhouse
2017-07-12

Introduction to Microwave Remote Sensing offers an extensive overview of this versatile and extremely precise technology for technically oriented undergraduates and graduate students. This textbook emphasizes an important shift in conceptualization and directs it toward students with prior knowledge of optical remote sensing: the author dispels any linkage between microwave and optical remote sensing. Instead, he constructs the concept of microwave remote sensing by comparing it to the process of audio perception, explaining the workings of the ear as a metaphor for microwave instrumentation. This volume takes an "application-driven" approach. Instead of describing the technology and then its uses, this textbook justifies the need for measurement then explains how microwave technology addresses this need. Following a brief summary of the field and a history of the use of microwaves, the book explores the physical properties of microwaves and the polarimetric properties of electromagnetic waves. It examines the interaction of microwaves with matter, analyzes passive atmospheric and passive surface measurements, and describes the operation of altimeters and scatterometers. The textbook concludes by explaining how high resolution images are created using radars, and how techniques of interferometry can be applied to both passive and active sensors.

Radar Networks - Hai Deng 2020-06-09

Radar networks are increasingly regarded as an efficient approach to enhancing radar capabilities in the face of popular anti-radar techniques and hostile operating environments. Reader-friendly and self-contained, this book provides a comprehensive overview of the latest radar networking technologies. The text addresses basic, relevant aspects of radar signal processing and statistical theories, including both civilian and military radar applications. It also discusses emerging topics that directly relate to networks, such as multiple-input-multiple-output (MIMO) radars, waveform design, and diversity via multiple transmitters. Other topics covered include target recognition and imaging using radar

networks. Features Gives a comprehensive view of the latest radar network technologies Covers both civilian and military applications of radar Provides basic statistics and signal processing necessary for understanding radar networks Includes up-to-date information on MIMO radars Presents waveform design and diversity for radar networks with multiple transmitters

Computer Processing of Remotely-Sensed Images - Paul M. Mather 2011-07-28

This fourth and full colour edition updates and expands a widely-used textbook aimed at advanced undergraduate and postgraduate students taking courses in remote sensing and GIS in Geography, Geology and Earth/Environmental Science departments. Existing material has been brought up to date and new material has been added. In particular, a new chapter, exploring the two-way links between remote sensing and environmental GIS, has been added. New and updated material includes: A website at www.wiley.com/go/mather4 that provides access to an updated and expanded version of the MIPS image processing software for Microsoft Windows, PowerPoint slideshows of the figures from each chapter, and case studies, including full data sets, Includes new chapter on Remote Sensing and Environmental GIS that provides insights into the ways in which remotely-sensed data can be used synergistically with other spatial data sets, including hydrogeological and archaeological applications, New section on image processing from a computer science perspective presented in a non-technical way, including some remarks on statistics, New material on image transforms, including the analysis of temporal change and data fusion techniques, New material on image classification including decision trees, support vector machines and independent components analysis, and Now in full colour throughout. This book provides the material required for a single semester course in Environmental Remote Sensing plus additional, more advanced, reading for students specialising in some aspect of the subject. It is written largely in non-technical language yet it provides insights into more advanced topics that some may consider too difficult for a non-mathematician to understand. The case studies available from the

website are fully-documented research projects complete with original data sets. For readers who do not have access to commercial image processing software, MIPS provides a licence-free, intuitive and comprehensive alternative.

Polarisation: Applications in Remote Sensing - Shane Cloude 2010
This is a monograph concerning the scattering of electromagnetic waves from surfaces to generate information for the purposes of remote sensing. It combines, for the first time, a treatment of two important new ideas, namely information from the orientation or polarisation of the wave and how it can be combined with interferometry.

Time-frequency Transforms for Radar Imaging and Signal Analysis - Victor C. Chen 2002

This resource introduces a new image formation algorithm based on time-frequency-transforms, showing its advantage over the more conventional Fourier-based image formation. Referenced with over 170 equations and 80 illustrations, the book presents new algorithms that help improve the result of radar imaging and signal processing.

Conference Record of the Thirty-Seventh Asilomar Conference on Signals, Systems & Computers - IEEE Signal Processing Society Staff 2003

Remote Sensing and Image Processing in Mineralogy - Maged Marghany 2022-03-03

Remote Sensing and Image Processing in Mineralogy reveals the critical tools required to comprehend the latest technology surrounding the remote sensing imaging of mineralogy, oil and gas explorations. It particularly focusses on multispectral, hyperspectral and microwave radar, as the foremost sources to understand, analyze and apply concepts in the field of mineralogy. Filling the gap between modern physics quantum theory and image processing applications of remote sensing imaging of geological features, mineralogy, oil and gas explorations, this reference is packed with technical details associated with the potentiality of multispectral, hyperspectral and synthetic aperture radar (SAR). The book also includes key methods needed to

extract the value-added information necessary, such as lineaments, gold and copper minings. This book also reveals novel speculation of quantum spectral mineral signature identifications, named as quantized Marghany's mineral spectral or Marghany Quantum Spectral Algorithms for Mineral identifications (MQSA). Rounding out with practical simulations of 4-D open-pit mining identification and monitoring using the hologram radar interferometry technique, this book brings an effective new source of technology and applications for today's minerology and petroleum engineers. Key Features • Helps develop new algorithms for retrieving mineral mining potential zones in remote sensing data. • Solves specific problems surrounding the spectral signature libraries of different minerals in multispectral and hyperspectral data. • Includes over 200 equations that illustrate how to follow examples in the book.

Synthetic Aperture Radar - John J. Kovaly 1976

Radar Interferometry - Ramon F. Hanssen 2006-04-18

This book is the product of five and a half years of research dedicated to the understanding of radar interferometry, a relatively new space-geodetic technique for measuring the earth's topography and its deformation. The main reason for undertaking this work, early 1995, was the fact that this technique proved to be extremely useful for wide-scale, fine-resolution deformation measurements. Especially the interferometric products from the ERS-1 satellite provided beautiful first results—several interferometric images appeared as highlights on the cover of journals such as Nature and Science. Accuracies of a few millimeters in the radar line of sight were claimed in semi-continuous image data acquired globally, irrespective of cloud cover or solar illumination. Unfortunately, because of the relative lack of supportive observations at these resolutions and accuracies, validation of the precision and reliability of the results remained an issue of concern. From a geodetic point of view, several survey techniques are commonly available to measure a specific geophysical phenomenon. To make an optimal choice between these techniques it is important to have a uniform and quantitative approach

for describing the errors and how these errors propagate to the estimated parameters. In this context, the research described in this book was initiated. It describes issues involved with different types of errors, induced by the sensor, the data processing, satellite positioning accuracy, atmospheric propagation, and scattering characteristics. Nevertheless, as the first item in the subtitle "Data Interpretation and Error Analysis" suggests, data interpretation is not always straightforward.

Mitigation of Hazardous Comets and Asteroids - M. J. S. Belton 2004-09-06

It is known that large asteroids and comets can collide with the Earth with severe consequences. Although the chances of a collision in a person's lifetime are small, collisions are a random process and could occur at any time. This book collects the latest thoughts and ideas of scientists concerned with mitigating the threat of hazardous asteroids and comets. It reviews current knowledge of the population of potential colliders, including their numbers, locations, orbits, and how warning times might be improved. The structural properties and composition of their interiors and surfaces are reviewed, and their orbital response to the application of pulses of energy is discussed. Difficulties of operating in space near, or on the surface of, very low mass objects are examined. The book concludes with a discussion of the problems faced in communicating the nature of the impact hazard to the public. *Topical Symposium on Combined Optical-microwave Earth and Atmosphere Sensing* - 1993

IGARSS 2002 - 2002

Advanced Ultrawideband Radar - James D. Taylor 2016-12-19

This book presents the latest theory, developments, and applications related to high resolution materials-penetrating sensor systems. An international team of expert researchers explains the problems and solutions for developing new techniques and applications. Subject areas include ultrawideband (UWB) signals propagation and scattering,

materials-penetrating radar techniques for small object detection and imaging, biolocation using holographic techniques, tomography, medical applications, nondestructive testing methods, electronic warfare principles, through-the-wall radar propagation effects, and target identification through measuring the target return signal spectrum changes.

IGARSS 2003 - 2003

Polarimetric SAR Imaging - Yoshio Yamaguchi 2020-08-18

Radar polarimetry has been highly sought after for its use in the precise monitoring of Earth's surface. Polarimetric SAR Imaging explains the basic concepts of polarimetry and its diverse applications including: deforestation, tree classification, landslide detection, tsunamis, volcano eruptions and ash distribution, snow accumulation, rice field monitoring, urban area exploration, ship detection, among other applications. The explanations use actual data sets taken by Advanced Land Observing Satellite (ALOS and ALOS2). With the increasing problems presented by climate change, there is a growing need for detailed earth observation using polarimetric data. As the treatment of vector nature of radar waves is complex, there is a gap between the theory and the application.

Polarimetric SAR Imaging: Theory and Applications addresses and fills this gap. Features: Provides cutting-edge polarimetric applications for earth observation with full color images. Includes detailed descriptions of theory, equations, expansions, and flowcharts, and numerous real examples. Explains concepts, data analysis, and applications in simple and clear language aimed at an intuitive comprehension. Provides specific and unique examples of PolSAR images derived from actual space and airborne systems (ALOS/ALOS2, PiSAR-x/L) Covers the wide range of the radar polarimetry, especially the decomposition of the polarimetry data, an original method developed by the author using the Japanese polarimetric SAR data Illustrated in full color using images generated by polarimetric techniques, this book is easy to understand and use for both student and expert, and is an excellent resource both in the classroom and in the field.

IEEE International Geoscience and Remote Sensing Symposium Proceedings - 2002

Spotlight-Mode Synthetic Aperture Radar: A Signal Processing Approach - Charles V. J. Jakowatz 2012-12-06

Modern airborne and spaceborne imaging radars, known as synthetic aperture radars (SARs), are capable of producing high-quality pictures of the earth's surface while avoiding some of the shortcomings of certain other forms of remote imaging systems. Primarily, radar overcomes the nighttime limitations of optical cameras, and the cloud- cover limitations of both optical and infrared imagers. In addition, because imaging radars use a form of coherent illumination, they can be used in certain special modes such as interferometry, to produce some unique derivative image products that incoherent systems cannot. One such product is a highly accurate digital terrain elevation map (DTEM). The most recent (ca. 1980) version of imaging radar, known as spotlight-mode SAR, can produce imagery with spatial resolution that begins to approach that of remote optical imagers. For all of these reasons, synthetic aperture radar imaging is rapidly becoming a key technology in the world of modern remote sensing. Much of the basic 'workings' of synthetic aperture radars is rooted in the concepts of signal processing. Starting with that premise, this book explores in depth the fundamental principles upon which the spotlight mode of SAR imaging is constructed, using almost exclusively the language, concepts, and major building blocks of signal processing. Spotlight-Mode Synthetic Aperture Radar: A Signal Processing Approach is intended for a variety of audiences. Engineers and scientists working in the field of remote sensing but who do not have experience with SAR imaging will find an easy entrance into what can seem at times a very complicated subject. Experienced radar engineers will find that the book describes several modern areas of SAR processing that they might not have explored previously, e.g. interferometric SAR for change detection and terrain elevation mapping, or modern non-parametric approaches to SAR autofocus. Senior undergraduates (primarily in electrical engineering) who have had courses in digital

signal and image processing, but who have had no exposure to SAR could find the book useful in a one-semester course as a reference.

Microwave Remote Sensing of Sea Ice - Frank D. Carsey 1992-04-08

Published by the American Geophysical Union as part of the Geophysical Monograph Series, Volume 68. Human activities in the polar regions have undergone incredible changes in this century. Among these changes is the revolution that satellites have brought about in obtaining information concerning polar geophysical processes. Satellites have flown for about three decades, and the polar regions have been the subject of their routine surveillance for more than half that time. Our observations of polar regions have evolved from happenstance ship sightings and isolated harbor icing records to routine global records obtained by those satellites. Thanks to such abundant data, we now know a great deal about the ice-covered seas, which constitute about 10% of the Earth's surface. This explosion of information about sea ice has fascinated scientists for some 20 years. We are now at a point of transition in sea ice studies; we are concerned less about ice itself and more about its role in the climate system. This change in emphasis has been the prime stimulus for this book.

IGARSS '88 - J. J. Hunt 1988

Remote Sensing of Wetlands - Ralph W. Tiner 2015-03-23

Effectively Manage Wetland Resources Using the Best Available Remote Sensing Techniques Utilizing top scientists in the wetland classification and mapping field, *Remote Sensing of Wetlands: Applications and Advances* covers the rapidly changing landscape of wetlands and describes the latest advances in remote sensing that have taken place over the pa

Signal Recovery and Synthesis - Optical Society of America 2001

EUSAR 2004 - 2004

Synthetic Aperture Radar Processing - Giorgio Franceschetti 2018-02-06

Synthetic Aperture Radar Processing simply and methodically presents principles and techniques of Synthetic Aperture Radar (SAR) image generation by analyzing its system transfer function. The text considers the full array of operation modes from strip to scan, emphasizes processing techniques, enabling the design of operational SAR codes. A simple example then follows. This book will be invaluable to all SAR scientists and engineers working in the field. It may be used as the basis for a course on SAR image generation or as a reference book on remote sensing. It contains a wide spectrum of information presented with clarity and rigor.

Remote Sensing of Snow and Ice - W. Gareth Rees 2005-08-12

Many advances in spaceborne instrumentation, remote sensing, and data analysis have occurred in recent years, but until now there has been no book that reflects these advances while delivering a uniform treatment of the remote sensing of frozen regions. *Remote Sensing of Snow and Ice* identifies unifying themes and ideas in these fields and presents them in a single volume. This book provides a comprehensive introduction to the remote sensing of the Earth's cryosphere. Explaining why cryospheric observations are important and why remote sensing observations are essential, it offers thorough surveys of the physical properties of ice and snow, and of current and emerging remote sensing techniques.

Presenting a technical review of how the properties of snow and ice relate to remote sensing observations, the book focuses on principles by which useful geophysical information becomes encoded into the electromagnetic radiation detected during the remote sensing process. The author then discusses in detail the application of remote sensing methods to snow, freshwater ice, glaciers, and icebergs. The book concludes with a summary that examines what remote sensing has revealed about the cryosphere, where major technical problems still exist, and how these problems can be addressed.