



## Neural Network Radiative Transfer for Imaging Spectroscopy

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**Abstract.** Visible/Shortwave InfraRed imaging spectroscopy provides valuable remote measurements of Earth's surface and atmospheric properties. These measurements generally rely on inversions of computationally-intensive Radiative Transfer Models (RTMs). RTMs' computational expense makes them difficult to use with high volume imaging spectrometers, and forces approximations such as lookup table interpolation and surface/atmosphere decoupling. These compromises limit the accuracy and flexibility of the remote retrieval; dramatic speed improvements in radiative transfer models could significantly improve the utility and interpretability of remote spectroscopy for Earth science. This study demonstrates that nonparametric function approximation with neural networks can replicate radiative transfer calculations over a relevant range of surface/atmosphere parameters. Incorporating physical knowledge into the network structure provides improved interpretability and model efficiency. We evaluate the approach in atmospheric correction of data from the PRISM airborne imaging spectrometer, and demonstrate accurate emulation of radiative transfer calculations which run several orders of magnitude faster than first-principles models. These results are particularly amenable to iterative spectrum fitting approaches, providing analytical benefits including statistically rigorous treatment of uncertainty and the potential to recover information on spectrally-broad signals.

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### 1 Introduction

Remote Visible / ShortWave InfraRed (V/SWIR) imaging spectroscopy, also known as hyperspectral imaging, is a powerful approach to map the composition, health, and biodiversity of Earth's ecosystems (ESAS, 2018). Remote sensing of the solar-reflected spectrum from 380-2500nm reveals physics and chemistry of many processes in Earth's surface/atmosphere system (Schaeppman et al., 2009), including: terrestrial plant health and traits (Asner et al., 2017; Ustin et al., 2004); biodiversity (Jetz et al., 2016); the condition and composition of aquatic, benthic, and near-shore ecosystems (Fichot et al., 2015; Hochberg, 2011); geology (Swayze et al., 2014); and trace greenhouse gases (Frankenberg et al., 2016). While Earth scientists aim to measure these geophysical variables, remote sensors can only measure the incident light at the sensor. Inferring geophysical

# Multi Scale Imaging Spectroscopy And Radiative Transfer In

**Shunlin Liang**



## **Multi Scale Imaging Spectroscopy And Radiative Transfer In:**

**Light Scattering Reviews, Volume 11** Alexander Kokhanovsky, 2016-05-12 This is the eleventh volume in the series Light Scattering Reviews devoted to current knowledge of light scattering problems and both experimental and theoretical research techniques related to their solution The focus of this volume is to describe modern advances in radiative transfer and light scattering optics This book brings together the most recent studies on light radiative transfer in the terrestrial atmosphere while also reviewing environmental polarimetry The book is divided into nine chapters the first four chapters review recent advances in modern radiative transfer theory and provide detailed descriptions of radiative transfer codes e.g. DISORT and CRTM Approximate solutions of integro differential radiative transfer equations for turbid media with different shapes spheres cylinders planeparallel layers are detailed chapters 5 to 8 focus on studies of light scattering by single particles and radially inhomogeneous media the final chapter discusses the environmental polarimetry of man made objects

**Handbook of Digital Imaging** Michael Kriss, 2015-02-16 A comprehensive and practical analysis and overview of the imaging chain through acquisition processing and display The Handbook of Digital Imaging provides a coherent overview of the imaging science amalgam focusing on the capture storage and display of images The volumes are arranged thematically to provide a seamless analysis of the imaging chain from source image acquisition to destination image print display The coverage is planned to have a very practical orientation to provide a comprehensive source of information for practicing engineers designing and developing modern digital imaging systems The content will be drawn from all aspects of digital imaging including optics sensors quality control colour encoding and decoding compression projection and display Contains approximately 50 highly illustrated articles printed in full colour throughout Over 50 Contributors from Europe US and Asia from academia and industry The 3 volumes are organized thematically for enhanced usability Volume 1 Image Capture and Storage Volume 2 Image Display and Reproduction Hardcopy Technology Halftoning and Physical Evaluation Models for Halftone Reproduction Volume 3 Imaging System Applications Media Imaging Remote Imaging Medical and Forensic Imaging 3 Volumes [www.handbookofdigitalimaging.com](http://www.handbookofdigitalimaging.com) **Remote Sensing Handbook, Volume III** Prasad S.

Thenkabail, 2024-11-29 Volume III of the Six Volume Remote Sensing Handbook Second Edition is focused on agriculture food security vegetation phenology rangelands soils and global biomass modeling mapping and monitoring using multi sensor remote sensing It discusses the application of remote sensing in agriculture systems analysis phenology cropland mapping and modeling terrestrial vegetation studies physically based models food and water security precision farming crop residues global view of rangelands and soils This thoroughly revised and updated volume draws on the expertise of a diverse array of leading international authorities in remote sensing and provides an essential resource for researchers at all levels interested in using remote sensing It integrates discussions of remote sensing principles data methods development applications and scientific and social context FEATURES Provides the most up to date comprehensive coverage of remote sensing science in

agriculture vegetation and soil studies Discusses and analyzes data from old and new generations of satellites and sensors spread across 60 years Provides comprehensive assessment of modeling mapping and monitoring agricultural crops vegetation and soils from wide array of sensors methods and techniques Includes numerous case studies on advances and applications at local regional and global scales Introduces advanced methods in remote sensing such as machine learning cloud computing and AI Highlights scientific achievements over the last decade and provides guidance for future developments This volume is an excellent resource for the entire remote sensing and GIS community Academics researchers undergraduate and graduate students as well as practitioners decision makers and policymakers will benefit from the expertise of the professionals featured in this book and their extensive knowledge of new and emerging trends **Advances in Geoscience and Remote Sensing** Gary Jedlovec, 2009-10-01 Remote sensing is the acquisition of information of an object or phenomenon by the use of either recording or real time sensing devices that is not in physical or intimate contact with the object such as by way of aircraft spacecraft satellite buoy or ship In practice remote sensing is the stand off collection through the use of a variety of devices for gathering information on a given object or area Human existence is dependent on our ability to understand utilize manage and maintain the environment we live in Geoscience is the science that seeks to achieve these goals This book is a collection of contributions from world class scientists engineers and educators engaged in the fields of geoscience and remote sensing **Scaling and Uncertainty Analysis in Ecology** Jianguo Wu, K. Bruce Jones, Harbin Li, Ori L. Loucks, 2006-07-02 Primarily the book draws together a series of important case studies to provide a comprehensive review and synthesis of the most recent concepts theories and methods in scaling and uncertainty analysis It compares current definitions and ideas concerning scale within a coherent framework and examines two key scaling approaches similarity based scaling which is rooted in the idea of similitude or self similarity and dynamic model based scaling which emphasizes processes and mechanisms With case studies focusing on issues ranging from population to ecosystem processes from biodiversity to landscape patterns and from basic research to multidisciplinary management and policy making the book will appeal to both researchers and practitioners working on landscape issues It will also provide a valuable resource for graduate students and professional trainees in ecology environmental policy resource management and global change science Remote Sensing for Environmental Monitoring, GIS Applications, and Geology, 2001 *Active Particles, Volume 2* Nicola Bellomo, Pierre Degond, Eitan Tadmor, 2019-08-22 This volume compiles eight recent surveys that present state of the art results in the field of active matter at different scales modeled by agent based kinetic and hydrodynamic descriptions Following the previously published volume these chapters were written by leading experts in the field and accurately reflect the diversity of subject matter in theory and applications Several mathematical tools are employed throughout the volume including analysis of nonlinear PDEs network theory mean field approximations control theory and flocking analysis The book also covers a wide range of applications including Biological

network formation Social systems Control theory of sparse systems Dynamics of swarming and flocking systems Stochastic particles and mean field approximations Mathematicians and other members of the scientific community interested in active matter and its many applications will find this volume to be a timely authoritative and valuable resource *Comprehensive Remote Sensing* Shunlin Liang,2017-11-08 Comprehensive Remote Sensing Nine Volume Set covers all aspects of the topic with each volume edited by well known scientists and contributed to by frontier researchers It is a comprehensive resource that will benefit both students and researchers who want to further their understanding in this discipline The field of remote sensing has quadrupled in size in the past two decades and increasingly draws in individuals working in a diverse set of disciplines ranging from geographers oceanographers and meteorologists to physicists and computer scientists Researchers from a variety of backgrounds are now accessing remote sensing data creating an urgent need for a one stop reference work that can comprehensively document the development of remote sensing from the basic principles modeling and practical algorithms to various applications Fully comprehensive coverage of this rapidly growing discipline giving readers a detailed overview of all aspects of Remote Sensing principles and applications Contains Layered content with each article beginning with the basics and then moving on to more complex concepts Ideal for advanced undergraduates and academic researchers Includes case studies that illustrate the practical application of remote sensing principles further enhancing understanding

**Snow Optics** Alexander Kokhanovsky,2025-06-14 This book is the first book of its kind focusing exclusively on the optical properties of snow As a complex and turbid medium snow is approached as a strongly light scattering in the visible spectrum medium with large nonspherical ice grains The book discusses both experimental and theoretical results as well as the remote sensing of snow using ground based airborne and satellite optical instrumentation The book will be of particular importance for researchers studying snow characteristics the size of grains snow pollution and albedo using various remote sensing techniques **Scientific and Technical Aerospace Reports** ,1993 *Geospatial Technologies for Crops and Soils* Tarik Mitran,Ram Swaroop Meena,Abhishek Chakraborty,2020-10-24 The sustainable development of the agriculture sector is the only option to meet the demands of increased and economically viable production in a changing climate This means there is a need to introduce the latest technologies to enhance production and also help policymakers make decisions for the future Geospatial technologies tools such as remote sensing geographical information systems GIS global positioning systems GPS and mobile web applications provide unique capabilities to analyze multi scale multi temporal datasets and support decision making in sustainable agriculture development and natural resources management Further the availability of reliable and timely geospatial information on natural resources and environmental conditions is essential for sustainable agricultural development and food security Since remote sensing solutions are fast non destructive and have large spatial coverage they can play a significant role in the identification inventory and mapping of land resources Over the past four decades remote sensing has proved to be a cost effective and powerful tool to assess crop and soil properties in varying

spatial and temporal scales using both visual and digital techniques Satellite remote sensing coupled with GIS mobile app based positional information has emerged as an efficient tool for optimizing input resources and minimizing cost of production and risk of biotic abiotic factors nature to promote sustainable agriculture This book comprehensively documents the applications of space based technologies for crop and soil assessments for the sustainable development of agriculture

**Electrical & Electronics Abstracts** ,1997    **Annali Di Geofisica** ,2002    **IEEE International Geoscience and Remote Sensing Symposium Proceedings** ,2003    **International Aerospace Abstracts** ,1999    **Optical Tomography and Spectroscopy of Tissue VI** Britton Chance,2005 Proceedings of SPIE offer access to the latest innovations in research and technology and are among the most cited references in patent literature    **IGARSS 2003** ,2003    **Proceedings of Optical Tomography and Spectroscopy of Tissue III : 24-28 January 1999, San Jose, California** Britton Chance,Society of Photo-optical Instrumentation Engineers,International Biomedical Optics Society,1999  
Dissertation Abstracts International ,2003    Science Abstracts ,1995

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