

ENCYCLOPEDIA *of*
REMOTE SENSING

Encyclopedia of Earth Sciences Series

ENCYCLOPEDIA OF REMOTE SENSING

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ENCYCLOPEDIA OF EARTH SCIENCES SERIES

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Contents

Contributors	xi	Calibration, Optical/Infrared Passive Sensors	47
Preface	xxiii	<i>Carol Bruegge</i>	
Acknowledgments	xxv	Calibration, Synthetic Aperture Radars	51
Acoustic Radiation	1	<i>Anthony Freeman</i>	
<i>Alain Weill</i>		Calibration, Scatterometers	54
Acoustic Tomography, Ocean	4	<i>David Long</i>	
<i>Brian Dushaw</i>		Climate Data Records	58
Acoustic Waves, Propagation	11	<i>Eric F. Wood</i>	
<i>Alain Weill</i>		Climate Monitoring and Prediction	58
Acoustic Waves, Scattering	13	<i>Mathew R. P. Sapiano</i>	
<i>Alain Weill</i>		Cloud Liquid Water	68
Aerosols	16	<i>Fuzhong Weng</i>	
<i>Ralph Kahn</i>		Cloud Properties	70
Agricultural Expansion and Abandonment	20	<i>Matthew Lebsock and Steve Cooper</i>	
<i>Jianguo Qi</i>		Coastal Ecosystems	73
Agriculture and Remote Sensing	22	<i>Xiaojun Yang</i>	
<i>Jerry Hatfield and Susan Moran</i>		Commercial Remote Sensing	78
Air Pollution	32	<i>William Gail</i>	
<i>Annamarie Eldering</i>		Cosmic-Ray Hydrometeorology	83
Atmospheric General Circulation Models	35	<i>Darin Desilets and Marek Zreda</i>	
<i>Joao Teixeira, Mark Taylor, Anders Persson</i>		Cost Benefit Assessment	86
<i>and Georgios Matheou</i>		<i>Molly Macauley</i>	
Calibration and Validation	39	Crop Stress	88
<i>Andreas Colliander</i>		<i>Susan Moran</i>	
Calibration, Microwave Radiometers	46	Cryosphere and Polar Region Observing System	91
<i>Christopher Ruf</i>		<i>Mark Drinkwater</i>	

vi	CONTENTS		
Cryosphere, Climate Change Effects <i>Aixue Hu</i>	98	Emerging Technologies, Radiometer <i>Todd Gaier</i>	186
Cryosphere, Climate Change Feedbacks <i>Peter J. Minnett</i>	101	Emerging Technologies, Sensor Web <i>Mahta Moghaddam, Agnelo Silva and Mingyan Liu</i>	190
Cryosphere, Measurements and Applications <i>Roger Barry</i>	104	Environmental Treaties <i>Alexander de Sherbinin</i>	196
Data Access <i>Ron Weaver</i>	119	Fields and Radiation <i>Frank S. Marzano</i>	201
Data Archival and Distribution <i>Mark A. Parsons</i>	121	Fisheries <i>Cara Wilson</i>	202
Data Archives and Repositories <i>Ruth Duerr</i>	127	Forestry <i>Dar Roberts</i>	210
Data Assimilation <i>Dennis McLaughlin</i>	131	Gamma and X-Radiation <i>Enrico Costa and Fabio Muleri</i>	219
Data Policies <i>Ray Harris</i>	134	Geodesy <i>Calvin Klatt</i>	228
Data Processing, SAR Sensors <i>Jakob van Zyl</i>	136	Geological Mapping Using Earth's Magnetic Field <i>Vernon H. Singhroy and Mark Pilkington</i>	232
Decision Fusion, Classification of Multisource Data <i>Björn Waske and Jón Atli Benediktsson</i>	140	Geomorphology <i>David Pieri</i>	237
Earth Radiation Budget, Top-of-Atmosphere Radiation <i>Bing Lin</i>	145	Geophysical Retrieval, Forward Models in Remote Sensing <i>Eugene Ustinov</i>	241
Earth System Models <i>Andrea Donnellan</i>	146	Geophysical Retrieval, Inverse Problems in Remote Sensing <i>Eugene Ustinov</i>	247
Electromagnetic Theory and Wave Propagation <i>Yang Du</i>	150	Geophysical Retrieval, Overview <i>Eugene Ustinov</i>	251
Emerging Applications <i>William Gail</i>	159	Global Climate Observing System <i>Jean-Louis Fellous</i>	254
Emerging Technologies <i>Jason Hyon</i>	162	Global Earth Observation System of Systems (GEOSS) <i>Steffen Fritz</i>	257
Emerging Technologies, Free-Space Optical Communications <i>Hamid Hemmati</i>	163	Global Land Observing System <i>Johannes A. Dolman</i>	261
Emerging Technologies, Lidar <i>David M. Tratt</i>	177	Global Programs, Operational Systems <i>Mary Kicza</i>	263
Emerging Technologies, Radar <i>Alina Mousseian</i>	185	GPS, Occultation Systems <i>Chi O. Ao</i>	264

CONTENTS		vii
Ice Sheets and Ice Volume <i>Robert Thomas</i>	269	Microwave Dielectric Properties of Materials <i>Martti Hallikainen</i> 364
Icebergs <i>Donald L. Murphy</i>	281	Microwave Horn Antennas <i>Yahya Rahmat-Samii</i> 375
International Collaboration <i>Lisa Robock Shaffer</i>	284	Microwave Radiometers <i>Niels Skou</i> 382
Ionospheric Effects on the Propagation of Electromagnetic Waves <i>Attila Komjathy</i>	286	Microwave Radiometers, Conventional <i>Niels Skou</i> 386
Irrigation Management <i>Steven R. Evett, Paul D. Colaizzi, Susan A. O'Shaughnessy, Douglas J. Hunsaker and Robert G. Evans</i>	291	Microwave Radiometers, Correlation <i>Christopher Ruf</i> 389
Land Surface Emissivity <i>Alan Gillespie</i>	303	Microwave Radiometers, Interferometers <i>Manuel Martin-Neira</i> 390
Land Surface Roughness <i>Thomas Farr</i>	311	Microwave Radiometers, Polarimeters <i>David Kunkee</i> 395
Land Surface Temperature <i>Alan Gillespie</i>	314	Microwave Subsurface Propagation and Scattering <i>Alexander Yarovoy</i> 398
Land Surface Topography <i>G. Bryan Bailey</i>	320	Microwave Surface Scattering and Emission <i>David R. Lyzenga</i> 403
Land-Atmosphere Interactions, Evapotranspiration <i>Joshua B. Fisher</i>	325	Mission Costs of Earth-Observing Satellites <i>Randall Friedl and Stacey Boland</i> 405
Landslides <i>Vernon H. Singhroy</i>	328	Mission Operations, Science Applications/Requirements <i>David L. Glackin</i> 407
Law of Remote Sensing <i>Joanne Irene Gabrynowicz</i>	332	Observational Platforms, Aircraft, and UAVs <i>Jeffrey Myers</i> 409
Lidar Systems <i>Robert Menzies</i>	334	Observational Systems, Satellite <i>David L. Glackin</i> 412
Lightning <i>Rachel I. Albrecht, Daniel J. Cecil and Steven J. Goodman</i>	339	Ocean Applications of Interferometric SAR <i>Roland Romeiser</i> 426
Limb Sounding, Atmospheric <i>Nathaniel Livesey</i>	344	Ocean Data Telemetry <i>Michael R. Prior-Jones</i> 429
Madden-Julian Oscillation (MJO) <i>Baijun Tian and Duane Waliser</i>	349	Ocean Internal Waves <i>Werner Alpers</i> 433
Magnetic Field <i>Nils Olsen</i>	358	Ocean Measurements and Applications, Ocean Color <i>Samantha Lavender</i> 437
Media, Electromagnetic Characteristics <i>Yang Du</i>	362	Ocean Modeling and Data Assimilation <i>Detlef Stammer</i> 446
		Ocean Surface Topography <i>Lee-Lueng Fu</i> 455

Ocean Surface Velocity <i>Bertrand Chapron, Johnny Johannessen and Fabrice Collard</i>	461	Radiation (Natural) Within the Earth's Environment <i>Anthony England</i>	558
Ocean, Measurements and Applications <i>Ian Robinson</i>	469	Radiation Sources (Natural) and Characteristics <i>Anthony England</i>	574
Ocean-Atmosphere Water Flux and Evaporation <i>W. Timothy Liu and Xiaosu Xie</i>	480	Radiation, Electromagnetic <i>Frank S. Marzano</i>	576
Operational Transition <i>Richard Anthes</i>	489	Radiation, Galactic, and Cosmic Background <i>David M. Le Vine</i>	581
Optical/Infrared, Atmospheric Absorption/ Transmission, and Media Spectral Properties <i>Gian Luigi Liberti</i>	492	Radiation, Multiple Scattering <i>Frank S. Marzano</i>	585
Optical/Infrared, Radiative Transfer <i>Knut Stamnes</i>	495	Radiation, Polarization, and Coherence <i>Yang Du</i>	588
Optical/Infrared, Scattering by Aerosols and Hydrometeors <i>Gian Luigi Liberti</i>	498	Radiation, Solar and Lunar <i>David M. Le Vine</i>	591
Pattern Recognition and Classification <i>Björn Waske and Jón Atli Benediktsson</i>	503	Radiation, Volume Scattering <i>Leung Tsang and Kung-Hau Ding</i>	595
Polar Ice Dynamics <i>James Maslanik</i>	509	Radiative Transfer, Solution Techniques <i>Rodolfo Guzzi</i>	606
Polar Ocean Navigation <i>Lawson Brigham</i>	512	Radiative Transfer, Theory <i>Frank S. Marzano</i>	624
Policies and Economics <i>Roberta Balstad</i>	515	Radio-Frequency Interference (RFI) in Passive Microwave Sensing <i>David Kunkke</i>	634
Precision Agriculture <i>Kelly Thorp</i>	515	Rainfall <i>Ralph Ferraro</i>	640
Processing Levels <i>Ron Weaver</i>	517	Rangelands and Grazing <i>Hunt E. Raymond, Jr.</i>	653
Public-Private Partnerships <i>William Gail</i>	520	Reflected Solar Radiation Sensors, Multiangle Imaging <i>David J. Diner</i>	658
Radar, Altimeters <i>Keith Raney</i>	525	Reflected Solar Radiation Sensors, Polarimetric <i>David J. Diner</i>	663
Radar, Scatterometers <i>David Long</i>	532	Reflector Antennas <i>Yahya Rahmat-Samii</i>	668
Radar, Synthetic Aperture <i>Keith Raney</i>	536	Remote Sensing and Geologic Structure <i>Vernon H. Singhroy and Paul Lowman</i>	681
Radars <i>Keith Raney</i>	547	Remote Sensing, Historical Perspective <i>Vincent V. Salomonson</i>	684

CONTENTS		ix
Remote Sensing, Physics and Techniques <i>David L. Glackin</i>	691	Terrestrial Snow <i>Son V. Nghiem, Dorothy K. Hall, James L. Foster and Gregory Neumann</i> 821
Resource Exploration <i>Fred A. Kruse and Sandra L. Perry</i>	702	Thermal Radiation Sensors (Emitted) <i>Simon Hook</i> 830
SAR-Based Bathymetry <i>Han Wensink and Werner Alpers</i>	719	Trace Gases, Stratosphere, and Mesosphere <i>Nathaniel Livesey</i> 834
Sea Ice Albedo <i>Donald Perovich</i>	722	Trace Gases, Troposphere - Detection from Space <i>Pietermel F. Levelt, J. P. Veeffkind and K. F. Boersma</i> 838
Sea Ice Concentration and Extent <i>Josefino C. Comiso</i>	727	Trafficability of Desert Terrains <i>Charles Hibbitts</i> 846
Sea Level Rise <i>Josh Willis</i>	743	Tropospheric Winds <i>Chris Velden</i> 849
Sea Surface Salinity <i>Gary Lagerloef</i>	747	Ultraviolet Remote Sensing <i>Arlin Krueger</i> 853
Sea Surface Temperature <i>Peter J. Minnett</i>	754	Ultraviolet Sensors <i>Arlin Krueger</i> 860
Sea Surface Wind/Stress Vector <i>W. Timothy Liu and Xiaosu Xie</i>	759	Urban Environments, Beijing Case Study <i>Son V. Nghiem, Alessandro Sorichetta, Christopher D. Elvidge, Christopher Small, Deborah Balk, Uwe Deichmann and Gregory Neumann</i> 869
Severe Storms <i>Charles A. III Doswell</i>	767	Urban Heat Island <i>Lela Prashad</i> 878
Snowfall <i>Ralf Bennartz</i>	780	Vegetation Indices <i>Alfredo Huete</i> 883
Soil Moisture <i>Yann Kerr</i>	783	Vegetation Phenology <i>John Kimball</i> 886
Soil Properties <i>Alfredo Huete</i>	788	Volcanism <i>Michael J. Abrams</i> 890
Solid Earth Mass Transport <i>Erik Ivins</i>	791	Water and Energy Cycles <i>Taikan Oki and Pat J.-F. Yeh</i> 895
Stratospheric Ozone <i>Michelle Santee</i>	796	Water Resources <i>Taikan Oki and Pat J.-F. Yeh</i> 903
Subsidence <i>Stuart Marsh and Martin Culshaw</i>	800	Water Vapor <i>Eric Fetzer</i> 909
Surface Radiative Fluxes <i>Rachel T. Pinker</i>	806	Weather Prediction <i>Peter Bauer</i> 912
Surface Truth <i>Christopher Ruf</i>	815	Wetlands <i>John Melack</i> 921
Surface Water <i>Michael Durand</i>	816	Author Index 923
		Subject Index 925

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Preface

During the past few decades, the emergence of remote sensing as a discipline – its science, instruments, missions, and applications – has inspired new and comprehensive studies of the Earth. Detailed observations of Earth’s land, ocean and atmospheric processes, and measurements of hitherto unexplored geophysical phenomena have been made possible by remote sensing instruments on ground-based, airborne, and spaceborne platforms. In particular, the unique vantage point of space provides spatially extensive and global perspectives of Earth. Frequent measurements, made hourly, daily, or weekly, over extended periods of years to decades, depending on the observing system and its configuration, have enabled comprehensive studies of Earth’s global system. Remote sensing has thus profoundly altered our understanding of the world in which we live, and has revolutionized the approaches we use to study our environment. Each year the growing number of Earth observing satellites, and the increasingly huge amounts of data and information provided, yield new knowledge and greater appreciation of the changes occurring on our planet, with important implications for future generations of Earth inhabitants. This encyclopedia is a comprehensive reference work on Earth remote sensing that presents the foundations, principles, and state of the art of remote sensing and describes the diverse applications it serves. It covers the concepts, techniques, instrumentation, data analysis, interpretation, and applications of remote sensing. This volume is part of the Encyclopedia of Earth Science series and is organized in the same style as other volumes in the series. The scientific disciplines covered by the series have all benefited in one way or another from the new understanding and discoveries afforded by remote sensing. It is thus timely for publication of an encyclopedia that can link these disciplines and the remote sensing techniques relevant to them in an integrated framework.

The focus of the encyclopedia is on remote sensing of Earth – its atmosphere, oceans, cryosphere, and land

surface and subsurface. Some of the techniques described in this volume have their origins in the disciplines of astronomy and astrophysics, and the study of the stars and planets for which, until recently, remote sensing was the only means of obtaining observational scientific data. When applied to Earth, these techniques have blossomed into a remarkably diverse and increasingly sophisticated set of scientific, technological, and computational approaches that all fall under the umbrella of remote sensing. The rapid growth of remote sensing as a discipline is evidenced by the large number of scientific journals now devoted to this field, and the number of courses and degree programs offered at universities around the world. The measurement and interpretation of radiation scattered and emitted by Earth’s atmosphere, surface, and subsurface is what we generally mean when we speak of Earth remote sensing. These measurements are obtained by instruments on remote platforms that include satellites, aircraft, balloons, drones, trucks, and stationary towers. Remote sensing instruments take many forms and are designed to measure electromagnetic radiation in specific wavelength regions of the broad electromagnetic spectrum; some instruments use other forms of radiation such as acoustic radiation. Measurements from the wide array of instruments, operating on the variety of available platforms available, can be processed and analyzed to extract characteristic information about Earth and its constituent biological, chemical, and physical structures, at resolutions from centimeters to thousands of kilometers. This remotely sensed information can be used on its own or combined with direct or ‘in situ’ measurements and geophysical models to give a more comprehensive understanding of the diversity of Earth science phenomena, some of which would be very limited without the unique perspective brought by remote sensing.

It is clear that an attempt to fully cover the breadth and depth of topics in remote sensing is a daunting task. Nevertheless, the need for a compendium that can be used as a reference work for this field, as a living document that

can be updated periodically to capture new advances, is a pressing one. It is with this aim in mind that the Springer *Encyclopedia of Remote Sensing* was conceived. Both this print version of the encyclopedia, which can be updated with revisions once every several years, and an online version, which can be updated on a more frequent basis by authors of individual entries, are provided. The online version can accommodate introduction of new entries as the need for new topics or treatments emerges. The encyclopedia entries cover topics that include broad introductory surveys as well as more in-depth treatment of some subjects. The entries treat topics of the physical principles of remote sensing in different wavelength regimes, propagation and scattering of radiation, geophysical models, remote sensing instrumentation, retrieval methods, remote sensing platforms and observational configurations. The models and retrieval methods are described with reference to specific applications in atmosphere, ocean, cryosphere, land, and solid earth geophysics. These applications include human impacts of climate change, and the enabling interdisciplinary science, as well as applications of direct societal benefit such as human health, food security, and prediction and mitigation of natural hazards. Earth remote sensing from space has flourished in the past few decades, and has become a truly global enterprise through development of international collaborations and partnerships, with investments from an increasing number of countries in building and operating satellite observational systems. Several entries in this volume have been devoted to describing these programs, and associated international policies and principles.

This encyclopedia is designed to support the needs of students, teachers, and professionals across a broad

spectrum of science, technology, and societal applications related to Earth remote sensing. The intended audience includes those with observational interests in the fields of oceanography, atmospheric sciences, meteorology, climate, cryospheric studies, hydrology, geology, solid earth geophysics, ecology, agronomy, forestry, environmental pollution, geography, land use and social studies, among others. The target audience also includes those with interests in remote sensing theory and practice, electromagnetic propagation, radiative transfer modeling, remote sensing instruments, spacecraft systems and orbits, environmental policy and decision-making, resource planning, and monitoring and forecasting of extreme events and natural hazards. In the commercial sector, economists, legal and insurance companies, and commercial and industrial concerns relying on the production, marketing and availability of value-added remote sensing products will also find the encyclopedia a valuable resource. The entries are presented in alphabetical order with titles that are designed to aid searches for specific topics. Cross-referencing using keywords to related entries is also provided to support efficient searches for information of interest to readers. The entries provide bibliographies for further in-depth reading. In summary, though it cannot be claimed that this encyclopedia represents an exhaustive treatment or complete coverage of the field of Earth remote sensing, it is hoped that the volume will serve as a comprehensive and dynamic introduction, and initial entry point, to inspire further reading and study of this exciting and rapidly developing field.

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Eni G. Njoku

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This leads to the largest group I wish to acknowledge, the authors of the 170 entries that range in size from several hundred words up to major contributions of several thousand words. Many authors took on more than one entry within their specialty area. Due to the length of time required to produce a volume of this type many

authors who submitted entries early had to wait a considerable amount of time before their entries were finally published. To these authors I especially wish to express my thanks for their patience and dedication to the completion of the project, and I hope they find the final volume worth the wait.

At the production end of the project has been the staff of Springer. Their help, understanding, and cooperation, especially when problems needed to be overcome, is something that cannot be appreciated enough. Their patient discussions and exchanges with the authors and board members did much to maintain the smooth progress of the project. Special acknowledgment should go to Petra van Steenberg and Sylvia Blago who provided me with encouragement through many difficult periods, and to Simone Giesler, all of who were involved with the encyclopedia from start to finish. I must also acknowledge the rewarding environment of my host institution and colleagues, all of whom provided a rich source of motivation and ideas in the field of remote sensing to inspire a publication of this type. My final appreciation goes to my wife Mary whose patience and support over the years has been a major factor in my ability to undertake this task, and to my son Eni Jr. who reminds me constantly of the power of positive thinking.