ENCYCLOPEDIA *of* REMOTE SENSING

Encyclopedia of Earth Sciences Series

ENCYCLOPEDIA OF REMOTE SENSING

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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.

September 2013 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.

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