2012

Preface to *Remote Sensing of Drought: Innovative Monitoring Approaches*

Brian D. Wardlow
University of Nebraska - Lincoln, bwardlow2@unl.edu

Published in *Remote Sensing of Drought: Innovative Monitoring Approaches,* edited by Brian D. Wardlow, Martha C. Anderson, & James P. Verdin (CRC Press/Taylor & Francis, 2012), pp xiii–xxii.

Preface

The motivation for this book on satellite remote sensing of drought stems from the increasing demand for drought-related information to address a wide range of societal issues (e.g., water scarcity, food security, and economic sustainability), the availability of unique Earth observations from many new satellite-based remote sensing instruments, and the advancement of analysis and modeling techniques. Collectively, the convergence of these factors has resulted in unprecedented new satellite-based estimates of evapotranspiration, rainfall, snow cover, subsurface moisture, and vegetation condition over large geographic areas that can support drought-monitoring activities. To date, a book solely dedicated to the topic of satellite remote sensing applications for drought monitoring has been lacking. The goal of this book is to provide a survey of many new, innovative remote sensing approaches that are either being applied or have the potential to be applied for operational drought monitoring and early warning. The book is by no means a comprehensive summary of all remote sensing–based methods that currently exist, but rather describes a representative set of the leading techniques that characterize major components of the hydrologic cycle related to drought.

The initial idea for this book was developed over the past five years as the National Drought Mitigation Center (NDMC) became increasingly involved in the development and application of information from several new remote sensing approaches in the U.S. Drought Monitor (USDM). These activities included the development of the Vegetation Drought Response Index (VegDRI) and the Vegetation Outlook (VegOut), as well as assisting other researchers to evaluate and integrate remote sensing–based evapotranspiration (ET), soil moisture, and terrestrial water storage (TWS) information. During this period, it became apparent that there was a wealth of new, innovative remote sensing–based tools emerging that offered new perspectives into the hydrologic cycle and could be applied to enhance drought monitoring and early warning. This was further reinforced at both the National Integrated Drought Information System (NIDIS) Contributions of Satellite Remote Sensing to Drought Monitoring Workshop in Boulder, Colorado (February 6–7, 2008), and the National Aeronautics and Space Administration (NASA) Drought Monitoring Tools Workshop in Silver Spring, Maryland (April 11–12, 2011), where a large number of new satellite-based remote sensing tools with a focus on drought applications were presented. At the same time, there is increasing interest from the drought community, both in the United States and internationally, to utilize satellite-based remote sensing information to improve our ability to characterize drought patterns at local scales, fill in data gaps for regions with sparse ground-based observation networks, and gain a more synoptic view of key environmental variables (e.g., evapotranspiration, groundwater, rainfall, and soil moisture) across large geographic areas than are captured in traditional, in situ measurement data sets. Several efforts are underway nationally

and internationally to better unify and integrate remote sensing products in drought monitoring, including NIDIS, the Group on Earth Observations (GEO), and the World Meteorological Organization (WMO).

Based on this collection of activities, it is apparent that satellite remote sensing will be increasingly looked upon to enhance global drought monitoring and to help address key related issues associated with food security and water resources. However, understanding the diversity and breadth of the types of remote sensing applications poised to fill this role has been challenging because these tools are often initially developed for applications other than drought, and the scientists behind these innovative approaches are from a broad range of disciplines such as agriculture, climatology, engineering, geography, hydrology, meteorology, and numerical modeling. As a result, much of the work and literature related to these tools has been presented in various professional journals across many disciplines, which can limit their visibility within the broader remote sensing and drought communities.

In 2009, I set out to develop a book dedicated to the topics of remote sensing and drought monitoring with the goal of providing a single publication that summarized many of these new leading satellite-based tools providing new observations of many critical hydrologic cycle components related to drought. Dr. Martha Anderson of the U.S. Department of Agriculture (USDA) Agricultural Research Service (ARS) and Dr. James Verdin of the U.S. Geological Survey (USGS) agreed to serve as coeditors, bringing their extensive experience and expertise in hydrologic applications of satellite remote sensing to the development of this book. The specific remote sensing techniques described in this book were selected for two primary reasons. First, they are either currently operational or hold the potential to be applied operationally in the near future, which is a critical requirement for routine drought monitoring. Second, they have the potential to be globally applicable and of interest to the international community. This book contains 14 chapters on remote sensing techniques that are organized into 4 parts associated with different components of the hydrologic cycle: vegetation (reflecting plant uptake and root-zone moisture deficiencies), evapotranspiration, soil moisture/groundwater, and precipitation in the form of rainfall and snow. An introductory chapter by Dr. Michael Hayes (lead author), the director of the NDMC, and colleagues is included to frame the broader drought picture and the past, present, and current role of satellite remote sensing to support drought monitoring and decision support. The final chapter provides the perspective of several leading remote sensing scientists on current challenges that need to be addressed by the remote sensing community to support drought applications, as well as a look to the future regarding new opportunities for the further advancement of satellite-based Earth observations in this application area.

Brian D. Wardlow
Assistant Professor and GIScience Program Area Leader
National Drought Mitigation Center
School of Natural Resources
University of Nebraska–Lincoln
Lincoln, Nebraska

Acknowledgments

The development of this book was the culmination of efforts from many people. First and foremost, my coeditors, Dr. Martha C. Anderson (U.S. Department of Agriculture [USDA] Agricultural Research Service [ARS]) and Dr. James P. Verdin (U.S. Geological Survey [USGS]), provided the vision to develop a publication that highlights many of the leading new remote sensing tools and techniques that offer considerable potential to advance the application of satellite-based information for operational drought monitoring and early warning. Their countless hours of reviewing the content of this book and the support from their respective organizations to participate in this endeavor are greatly appreciated. I would like to acknowledge the book series editor, Dr. Donald A. Wilhite, for his encouragement to develop the first book dedicated to the topic of satellite remote sensing and drought within his book series Drought and Water Crises: Science, Technology, and Management Issues. A special thanks to Dr. Michael Hayes and my colleagues at the National Drought Mitigation Center (NDMC) for their support and for providing me the time to complete this book. The editorial guidance by Irma Shagla-Britton and Kari Budyk of CRC Press and Deborah Wood of the NDMC was invaluable throughout the book's development.

The contributions of the many chapter authors deserve a special acknowledgment because this book would not have been possible without their efforts. Each author was asked to provide a detailed description of satellite-based, drought monitoring tools they have worked to develop, along with examples of how these tools can be applied in practice and what new information remote sensing conveys in comparison with standard ground-based measurement networks. Each chapter was the product of an iterative development and review process involving the authors and editors to ensure consistency and completeness of the book's material. The editors wish to thank the authors for their patience and commitment during this process; it was greatly appreciated. Last, on behalf of my coeditors, I extend my gratitude to the numerous peer reviewers for ensuring that the remote sensing techniques were presented in a complete and understandable manner for readers. A number of individuals participated in the peer review, including Jude Kastens (Kansas Applied Remote Sensing [KARS] Program, University of Kansas), book chapter authors Jesslyn Brown (USGS Earth Resources and Observation Science [EROS] Center), Chris Hain (National Oceanic and Atmospheric Administration [NOAA] National Environmental Satellite, Data, and Information Service [NESDIS]), William Kustas (USDA-ARS), and John Mecikalski (University of Alabama-Huntsville).

Brian D. Wardlow

Editors

Brian D. Wardlow is an assistant professor and GIScience program area leader for the National Drought Mitigation Center (NDMC) in the School of Natural Resources at the University of Nebraska–Lincoln. His work focuses on the development of new remote sensing techniques for drought monitoring, transitioning new remote sensing tools from research to operational use in drought monitoring and early warning systems, and outreach and training in the United States and internationally on the application of these tools. Before joining the NDMC, he worked as a remote sensing specialist at the U.S. Geological Survey (USGS) Earth Resources and Observation Science (EROS) Center, working on the National Land Cover Dataset (NLCD) project. During his PhD program, he was also a graduate research fellow as part of the National Aeronautics and Space Administration's Earth System Science Graduate Fellowship program, investigating the application of time-series moderate resolution imaging spectroradiometer vegetation index data for regional-scale, crop-related land use/land cover mapping and monitoring in the U.S. Central Great Plains. His primary research interests are focused on the application of remote sensing and geographic information systems for drought monitoring and impact assessment, land use/land cover characterization, vegetation phenology, and agricultural and natural resources management and monitoring. He is currently a member of the NASA SMAP Application and National Phenology Network working groups. Dr. Wardlow received his BSc in geography from Northwest Missouri State University, an MA in geography from Kansas State University, and a PhD in geography from the University of Kansas.

Martha C. Anderson is a physical scientist in the Hydrology and Remote Sensing Laboratory of the U.S. Department of Agriculture's (USDA) Agricultural Research Service in Beltsville, Maryland. Prior to her position with the USDA, Dr. Anderson was a research scientist at the University of Wisconsin, working on integrating satellite and synoptic weather information into agricultural decision-making tools. Her current research interests focus on mapping water, energy, and carbon land-surface fluxes at field to continental scales using multisensor and multiwavelength remote sensing data, with applications in drought monitoring and soil moisture estimation. She is currently a member of the Landsat Science Team and the HyspIRI Science Study Group. Dr. Anderson received her BA in physics from Carleton College, Northfield, Minnesota, and her PhD in astrophysics from the University of Minnesota.

James P. Verdin is a physical scientist with the U.S. Geological Survey (USGS), Earth Resources Observation and Science (EROS) Center. He is currently assigned to work in the National Integrated Drought Information System (NIDIS) Program Office at National Oceanic and Atmospheric Administration (NOAA) in Boulder, Colorado. He coordinates activities for the NIDIS pilot drought early

warning system for the Upper Colorado River Basin. Since 1995, he has led USGS activities in support of the USAID Famine Early Warning Systems Network. His research interests focus on the use of remote sensing and modeling to address questions of hydrology, agriculture, and hydroclimatic hazards. He has extensive experience in geographic characterization of drought hazards for food security assessment in Africa, Asia, and Latin America. He recently took on leadership of efforts to estimate crop water use with remote sensing for the USGS National Water Census. Before joining the USGS, he worked for 11 years with the U.S. Bureau of Reclamation, including a 3-year assignment in Brazil. Dr. Verdin received his BSc and MSc in civil and environmental engineering from the University of Wisconsin, Madison, and Colorado State University, respectively, and his PhD in geography from the University of California, Santa Barbara.

Contributors

Amir AghaKouchak
Department of Civil and Environmental Engineering
University of California, Irvine
Irvine, California

David Allured
Physical Science Division
Earth System Research Laboratory
National Oceanic and Atmospheric Administration
Boulder, Colorado

Martha C. Anderson
Hydrology and Remote Sensing Laboratory
Agricultural Research Service
U.S. Department of Agriculture
Beltsville, Maryland

Assaf Anyamba
Universities Space Research Association & Biospheric Sciences Laboratory
National Aeronautics and Space Administration
Goddard Space Flight Center
Greenbelt, Maryland

Stefanie Bohms
Earth Resources Observation and Science Center
U.S. Geological Survey
Sioux Falls, South Dakota

Jesslyn F. Brown
Earth Resources Observation and Science Center
U.S. Geological Survey
Sioux Falls, South Dakota

Karin Callahan
National Drought Mitigation Center
Center for Advanced Land Management Information Technology
School of Natural Resources
University of Nebraska–Lincoln
Lincoln, Nebraska

Steven K. Chan
Jet Propulsion Laboratory
California Institute of Technology
Pasadena, California

Bradley D. Doorn
Earth Science Division
National Aeronautics and Space Administration
Washington, District of Columbia

Michael Ek
Environmental Modeling Center
National Centers for Environmental Prediction
National Oceanic and Atmospheric Administration
Camp Springs, Maryland

Ralph Ferraro
National Environmental Satellite, Data, and Information Service
National Oceanic and Atmospheric Administration
Camp Springs, Maryland

Christopher Funk
Earth Resources Observation and Science Center
U.S. Geological Survey
Sioux Falls, South Dakota

Xiaogang Gao
Department of Civil and Environmental Engineering
University of California, Irvine
Irvine, California

Christopher R. Hain
National Environmental Satellite, Data, and Information Service
National Oceanic and Atmospheric Administration
Camp Springs, Maryland

Michael J. Hayes
National Drought Mitigation Center
School of Natural Resources
University of Nebraska–Lincoln
Lincoln, Nebraska

Kuolin Hsu
Department of Civil and Environmental Engineering
University of California, Irvine
Irvine, California

Eric Hunt
National Drought Mitigation Center
School of Natural Resources
University of Nebraska–Lincoln
Lincoln, Nebraska

Bisher Imam
Department of Civil and Environmental Engineering
University of California, Irvine
Irvine, California

Felix Kogan
National Environmental Satellite, Data, and Information Service
National Oceanic and Atmospheric Administration
Camp Springs, Maryland

Cezar Kongoli
National Environmental Satellite, Data, and Information Service
National Oceanic and Atmospheric Administration
Camp Springs, Maryland

William P. Kustas
Hydrology and Remote Sensing Laboratory
Agricultural Research Service
U.S. Department of Agriculture
Beltsville, Maryland

Doug LeComte
Climate Prediction Center
National Oceanic and Atmospheric Administration
Camp Springs, Maryland

Lifeng Luo
Department of Geography
Michigan State University
East Lansing, Michigan

Michael T. Marshall
Department of Geography
University of California, Santa Barbara
Santa Barbara, California

John R. Mecikalski
Department of Atmospheric Science
University of Alabama in Huntsville
Huntsville, Alabama

Joel Michaelsen
Department of Geography
University of California, Santa Barbara
Santa Barbara, California

Kenneth E. Mitchell
Environmental Modeling Center
National Centers for Environmental Prediction
National Oceanic and Atmospheric Administration
Camp Springs, Maryland

Gregory Neumann
Jet Propulsion Laboratory
California Institute of Technology
Pasadena, California

Son V. Nghiem
Jet Propulsion Laboratory
California Institute of Technology
Pasadena, California

Stefan Niemeyer
Institute for Environment and Sustainability
Joint Research Centre
European Commission
Ispra, Italy

Agustin Pimstein
Faculty of Agronomy and Forestry Engineering
Department of Fruit Production and Enology
The Pontifical Catholic University of Chile
Santiago, Chile

Matthew Rodell
Hydrological Sciences Laboratory
National Aeronautics and Space Administration
Goddard Space Flight Center
Greenbelt, Maryland

Peter Romanov
National Environmental Satellite, Data, and Information Service
National Oceanic and Atmospheric Administration
Camp Springs, Maryland

Matthew Rosencrans
Climate Prediction Center
National Oceanic and Atmospheric Administration
Camp Springs, Maryland

Simone Rossi
Institute for Environment and Sustainability
Joint Research Centre
European Commission
Ispra, Italy
and
Food and Agriculture Organization of the United Nations
Rome, Italy

Gabriel B. Senay
Earth Resources Observation and Science Center
U.S. Geological Survey
Sioux Falls, South Dakota

Justin Sheffield
Department of Civil and Environmental Engineering
Princeton University
Princeton, New Jersey

Soroosh Sorooshian
Department of Civil and Environmental Engineering
University of California, Irvine
Irvine, California

Gregory J. Story
West Gulf River Forecast Center
National Weather Service
Fort Worth, Texas

Mark D. Svoboda
National Drought Mitigation Center
School of Natural Resources
University of Nebraska–Lincoln
Lincoln, Nebraska

Sharmistha Swain
National Drought Mitigation Center
School of Natural Resources
University of Nebraska–Lincoln
Lincoln, Nebraska

Tsegaye Tadesse
National Drought Mitigation Center
School of Natural Resources
University of Nebraska–Lincoln
Lincoln, Nebraska

Compton J. Tucker
Hydrological and Biospheric Sciences Laboratory
National Aeronautics and Space Administration
Goddard Space Flight Center
Greenbelt, Maryland

James P. Verdin
Earth Resources Observation and Science Center
U.S. Geological Survey
Sioux Falls, South Dakota

Brian D. Wardlow
National Drought Mitigation Center
School of Natural Resources
University of Nebraska–Lincoln
Lincoln, Nebraska

Eric F. Wood
Department of Civil and Environmental Engineering
Princeton University
Princeton, New Jersey

Youlong Xia
Environmental Modeling Center
National Centers for Environmental Prediction
National Oceanic and Atmospheric Administration
Camp Springs, Maryland

Xiwu Zhan
Center for Satellite Applications and Research
National Environmental Satellite, Data, and Information Service
National Oceanic and Atmospheric Administration
Camp Springs, Maryland