FOURTH EDITION

Introduction to REMOTE SENSING

JAMES B. CAMPBELL

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THE GUILFORD PRESS
New York · London

© 2007 The Guilford Press
A Division of Guilford Publications, Inc.
72 Spring Street, New York, NY 10012
www.guilford.com

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Printed in the United States of America

This book is printed on acid-free paper.

Last digit is print number: 9 8 7 6 5 4 3 2 1

Library of Congress Cataloging-in-Publication Data

Campbell, James B., 1944–
Introduction to remote sensing / by James B. Campbell. — 4th ed.
p. cm.
Includes bibliographical references and index.
ISBN-10: 1-59385-319-X (hardcover) ISBN-13: 978-1-59385-319-8 (hardcover)
1. Remote sensing. I. Title.
G70.4.C23 2007
621.36′78—dc22 2006022914

To the memory of my parents,

JAMES BATCHELDER CAMPBELL
1911–1982

and

DOROTHY ANN TISON CAMPBELL
1917–1987

Preface

Even a few decades ago, the diversity and capabilities of today's remote sensing systems would have been unimaginable, even for the most committed visionaries. Likewise, few could have anticipated the development of the analytical tools and techniques now available for examination of remotely sensed data, the widespread availability of remotely sensed imagery, or the multiplicity of its uses throughout society. These developments alone present a challenge for any text on this subject.

Further, the tremendous volume of relevant material, and the thorough access provided by the World Wide Web (WWW), can cause anyone to ponder the role of a university text—isn't its content already available to any reader? Despite the value of the WWW as a resource for any student of remote sensing, its complexity and dynamic character actually increases, rather than diminishes, the value of an introductory text. Because of the overwhelming volume of unstructured information on the WWW, students often require a guide to provide structure and context that enables them to select and assess the many sources at hand. In this context, then, this text forms a guide for the use of the many other sources available—sources that may be more comprehensive and up to date than the context of any text could be. Thus, I encourage students to use this volume in partnership with online materials—the text as a guide, and the online materials as a reference for additional depth.

Instructors should supplement the content of this volume with material of significance in their own programs. Supplementary materials will, of course, vary greatly from one institution to the next, depending on access to facilities and equipment, as well as on the varying expectations and interests of instructors, students, and curricula. It is assumed that the text will be used as the basis for readings and lectures, and that most courses will include at least brief laboratory exercises that permit students to examine more images than can be presented here. Because access to specific equipment and software varies so greatly, and because of the great variation in emphasis noted above, this book does not include laboratory exercises. But each chapter does conclude with a set of Review Questions and problems that can assist students in review and assessment of concepts and material.

For students who intend to specialize in remote sensing, this text offers not only an introduction but also a framework for subjects to be studied in greater detail. Students who do plan specialization in remote sensing should consult their instructors to plan a comprehensive course of study based on work in several disciplines as discussed in Chapter 1. This approach is reflected

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in the text itself: it introduces students to principal topics of significance for remote sensing, but recognizes that students will require additional depth in their chosen fields of study.

For those students who do not intend to pursue remote sensing beyond the introductory level, this book serves as an overview and introduction, so that they can understand remote sensing, its applications in varied disciplines, and its significance in today's world. For many, the primary emphasis will be study of those chapters and methods of greatest significance in their major field of study.

Instructors may benefit from a preview of some of the changes in the fourth edition. Material concerning lidar has been presented in its own chapter, in recognition of the increasing maturity of this technology and the accelerating pace of its applications within the remote sensing arena. Lidar's significance will continue to grow, and will likely continue to displace important applications now based on photogrammetric analysis of aerial photography.

Use of remote sensing to monitor phenology (seasonal changes in both agricultural and native plant cover) opens opportunities for improvements in analysis of agricultural landscapes, derivation of land-cover classes (based on differences in phenological cycles), and examination of land-use change.

Further, new material on remote sensing applications for plant pathology presented in Chapter 17 has significance for the growing awareness of the impact of introduced plant pathogens and their effect on native flora and on important agricultural crops. Remote sensing is an important tool (among others) in society's efforts to address these important challenges, so it is important to introduce to students to this topic, even at an introductory level.

Other developments present more problematic issues for the structure of this text. As these words are written, it is clear that there will be a programmatic gap in Landsat coverage—even if current problems are resolved, its remaining days are numbered. The nature of programs to acquire substitute imagery, and the design of a replacement system, are far too uncertain to discuss at this time. Likewise, although the sensors that form the core global remote sensing programs described in Chapter 21 will be in operation for many more years, there are no programs now under way to extend these systems, so they will expire in due course without a clear avenue to continue their missions. Therefore, although both of these topics will continue to be significant for the field of remote sensing, the specifics are rather murky, and will continue to remain so for some years to come. Instructors should not neglect to discuss these topics, but should monitor current developments to provide details as needed.

Other changes for the fourth edition include the revision of illustrations for Chapter 5 (image interpretation) to include more concrete examples focused on practical needs. Material in earth sciences (Chapter 18), land use and land cover (Chapter 20), and remote sensing and geographic information systems (Chapter 16) has been restructured to provide students with content of a more practical nature, with new illustrations.

To permit instructors to tailor assignments to meet specific structures for their own courses, content is organized at several levels. At the broadest level, a rough division into four parts offers a progression in the subjects presented, with only a few concessions to practicality (such as placing the "Image Interpretation" chapter under "Image Acquisition" rather than in its logical position in "Analysis"). Each part consists of two or more chapters organized as follows:

Part I. Foundations

1. History and Scope of Remote Sensing
2. Electromagnetic Radiation

Part II. Image Acquisition

3. Photographic Sensors
4. Digital Data
5. Image Interpretation
6. Land Observation Satellites
7. Active Microwave
8. Lidar
9. Thermal Radiation
10. Image Resolution

Part III. Analysis

11. Preprocessing
12. Image Classification
13. Field Data
14. Accuracy Assessment
15. Hyperspectral Remote Sensing

Part IV. Applications

16. Remote Sensing and Geographic Information Systems
17. Plant Sciences
18. Earth Sciences
19. Hydrospheric Sciences
20. Land Use and Land Cover
21. Global Remote Sensing

Conclusion: The Outlook for the Field of Remote Sensing

The 21 numbered chapters each constitute more or less independent units that can be selected as necessary to meet the specific needs of each instructor. Numbered sections within chapters form even smaller units that can be selected and combined with other material as desired by the instructor.

I gratefully acknowledge the contributions of those who assisted in identifying and acquiring images used in this book. Individuals and organizations in both private industry and governmental agencies have been generous with their advice and support. Daedalus Enterprises Incorporated, EROS Data Center, Digital Globe, Environmental Research Institute of Michigan, EOSAT, GeoSpectra Corporation, IDELIX Software, and SPOT Image Corporation are among the organizations that assisted my search for suitable images. For the fourth edition, I am grateful for the continued support of these organizations and for the assistance of the U.S. Geological Survey, RADARSAT International, Earth Satellite Corporation, and the Jet Propulsion Laboratory. Also, I gratefully recognize the assistance of EarthData, Emerge, and Orbital Imaging Corporation.

Much of what is good about this book is the result of the assistance of colleagues in many disciplines in universities, corporations, and research institutions who have contributed through their correspondence, criticisms, explanations, and discussions. Students in my classes have, through their questions, mistakes, and discussions, contributed greatly to my own learning, and therefore to this volume. Faculty who use this text at other universities have provided suggestions and responded to questionnaires designed by The Guilford Press.

At Guilford, Janet Crane, Peter Wissoker, and Kristal Hawkins guided preparation of the earlier editions. For these earlier editions I am grateful for the special contributions of Chris Hall, Soren Popescu, Russ Congalton, Bill Carstensen, Don Light, David Pitts, and Jim Merchant. Buella Prestrude and George Will assisted me with preparation of the illustrations.

Many individuals have supported preparation of this edition, although none are responsible for the errors and shortcomings that remain. The assistance of Chris North, Bill Carstensen, Steve Prisley, and Maggi Kelly is gratefully acknowledged, as are the suggestions and corrections offered by readers. Teaching assistants, including Dave Trible, Sara Hyland, and Sam Chambers, have contributed to development of materials used in this edition. Anonymous reviewers provided insightful and detailed comments and critiques that extended beyond the scope of the usual manuscript reviews. At The Guilford Press, Kristal Hawkins has guided the launch of this fourth edition. Seymour Weingarten, editor in chief, continued his support of this project through the course of its four editions.

Users of this text can inform the author of errors, suggestions, and other comments at:

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Blacksburg, Virginia

List of Plates

PLATE 1. Color and color infrared aerial photographs, Torch Lake, Michigan
PLATE 2. Digital color infrared image, Oahu, Hawaii
PLATE 3. High-altitude aerial photograph, Corpus Christi, Texas, January 31, 1995
PLATE 4. Density slicing
PLATE 5. Thematic mapper color composite (bands 1, 3, and 4)
PLATE 6. SPOT color composite
PLATE 7. SeaWifS image, February 26, 2000
PLATE 8. IKONOS multispectral imagery, Montego Bay, Jamaica
PLATE 9. Aral Sea shrinkage, 1962–1994
PLATE 10. Multifrequency SAR image, Barstow, California
PLATE 11. Shuttle imaging radar images (SIR-C/X-SAR) of the region near Mount Pinatubo, Philippines
PLATE 12. Radar interferometry, Honolulu, Hawaii, February 2000
PLATE 13. Radar interferometry, Missouri River floodplain
PLATE 14. Interpolation of lidar returns
PLATE 15. Lidar data used to model the built environment
PLATE 16. Glideslope surface estimated from lidar data
PLATE 17. Thermal images of residential structures showing the thermal properties of their separate elements
PLATE 18. Landscape near Erfurt, Germany, as observed by a thermal scanner
PLATE 19. Applications Explorer Mission 1 (HCMM) image of northeastern United States and southeastern Canada, May 11, 1978
PLATE 20. Image cubes. Two examples of AVIRIS images displayed in image cube format
PLATE 21. Example of a ratio image
PLATE 22. Rice crop-monitoring, Mekong Delta, Vietnam
PLATE 23. Band ratios used to study lithologic differences, Cuprite, Nevada, mining district
PLATE 24. Chesapeake Bay, as photographed June 8, 1991 from the space shuttle
PLATE 25. Belgian port of Zeebrugge
PLATE 26. AVHRR sea-surface temperature, Duck, North Carolina
PLATE 27. Landsat TM quarter scene depicting Santa Rosa del Palmar, Bolivia
PLATE 28. Images depicting global remote sensing data

Contents

Preface xv
List of Tables xix
List of Figures xxi
List of Plates xxx

PART I. FOUNDATIONS

1. History and Scope of Remote Sensing **3**
1.1. Introduction 3
1.2. Definitions 4
1.3. Milestones in the History of Remote Sensing 7
1.4. Overview of the Remote Sensing Process 14
1.5. A Specific Example 15
1.6. Key Concepts of Remote Sensing 18
1.7. Career Preparation and Professional Development 21
Review Questions 25
References 26

2. Electromagentic Radiation **28**
2.1. Introduction 28
2.2. The Electromagnetic Spectrum 28
2.3. Major Divisions of the Electromagnetic Spectrum 30
2.4. Radiation Laws 33
2.5. Interactions with the Atmosphere 35
2.6. Interactions with Surfaces 44
2.7. Summary: Three Models for Remote Sensing 49
Review Questions 51
References 52

PART II. IMAGE ACQUISITION

3. Photographic Sensors **55**
3.1. Introduction 55
3.2. The Aerial Camera 56

3.3. Kinds of Aerial Cameras 61
3.4. Black-and-White Aerial Films 62
3.5. Color Reversal Films 71
3.6. Color Infrared Films 72
3.7. Film Format and Annotation 74
3.8. Geometry of the Vertical Aerial Photograph 74
3.9. Coverage by Multiple Photographs 79
3.10. Photogrammetry 86
3.11. Digital Photography 87
3.12. Softcopy Photogrammetry 87
3.13. Sources of Aerial Photography 87
3.14. Summary 90
Review Questions 90
References 91
YOUR OWN INFRARED PHOTOGRAPHS 92
YOUR OWN 3D PHOTOGRAPHS 93

4. Digital Data **95**
4.1. Introduction 95
4.2. Electronic Imagery 95
4.3. Spectral Sensitivity 101
4.4. Digital Data 102
4.5. Data Formats 104
4.6. Equipment for Digital Analysis 107
4.7. Image-Processing Software 114
4.8. The Internet 116
4.9. Summary 120
Review Questions 121
References 122

5. Image Interpretation **123**
5.1. Introduction 123
5.2. The Context for Image Interpretation 124
5.3. Image Interpretation Tasks 125
5.4. Elements of Image Interpretation 126
5.5. Image Interpretation Strategies 131
5.6. Collateral Information 133
5.7. Imagery Interpretability Rating Scales 133
5.8. Image Interpretation Keys 133
5.9. Interpretive Overlays 134
5.10. Photomorphic Regions 135
5.11. Significance of Context 136
5.12. Image Interpretation Equipment 138
5.13. Use of the Pocket Stereoscope 146
5.14. Image Scale Calculations 149
5.15. Interpretation of Digital Imagery 152

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5.16. Summary 156
Review Questions 157
References 158

6. Land Observation Satellites **160**
6.1. Satellite Remote Sensing 160
6.2. Landsat Origins 160
6.3. Satellite Orbits 162
6.4. The Landsat System 164
6.5. Multispectrai Scanner Subsystem Images 169
6.6. Landsat Thematic Mapper 174
6.7. Administration of the Landsat Program 179
6.8. Current Satellite Systems 179
6.9. Computer Searches 192
6.10. Summary 194
Review Questions 195
References 196
CORONA 197

7. Active Microwave **204**
7.1. Introduction 204
7.2. Active Microwave 204
7.3. Geometry of the Radar Image 208
7.4. Wavelength 211
7.5. Penetration of the Radar Signal 213
7.6. Polarization 213
7.7. Look Direction and Look Angle 215
7.8. Real Aperture Systems 216
7.9. Synthetic Aperture Systems 219
7.10. Interpreting Brightness Values 220
7.11. Satellite Imaging Radars 224
7.12. Radar Interferometry 234
7.13. Summary 237
Review Questions 237
References 238

8. Lidar **239**
8.1. Introduction 239
8.2. Profiling Lasers 240
8.3. Imaging Lidars 241
8.4. Lidar Imagery 242
8.5. Types of Imaging Lidars 243
8.6. Processing Lidar Image Data 244
8.7. Summary 248
Review Questions 249
References 250

9. Thermal Radiation **252**
9.1. Introduction 252
9.2. Thermal Detectors 253
9.3. Thermal Radiometry 255
9.4. Microwave Radiometers 258
9.5. Thermal Scanners 259
9.6. Thermal Properties of Objects 260
9.7. Geometry of Thermal Images 263
9.8. The Thermal Image and Its Interpretation 264
9.9. Heat Capacity Mapping Mission 272
9.10. Landsat Multispectral Scanner and Thematic Mapper Thermal Data 274
9.11. Summary 275
Review Questions 276
References 277

10. Image Resolution **279**
10.1. Introduction and Definitions 279
10.2. Target Variables 280
10.3. System Variables 281
10.4. Operating Conditions 281
10.5. Measurement of Resolution 282
10.6. Mixed Pixels 284
10.7. Spatial and Radiometric Resolution: Simple Examples 288
10.8. Interactions with the Landscape 289
10.9. Summary 291
Review Questions 292
References 293

PART III. ANALYSIS

11. Preprocessing **297**
11.1. Introduction 297
11.2. Feature Extraction 297
11.3. Subsets 300
11.4. Radiometric Preprocessing 302
11.5. Image Matching 309
11.6. Geometric Correction by Resampling 310
11.7. Map Projections for Representing Satellite Images and Ground Tracks 315
11.8. Effects of Preprocessing 317
11.9. Data Fusion 318
11.10. Summary 320
Review Questions 320
References 321

12. Image Classification **324**
12.1. Introduction 324
12.2. Informational Classes and Spectral Classes 326

12.3. Unsupervised Classification 328
12.4. Supervised Classification 338
12.5. Ancillary Data 353
12.6. Fuzzy Clustering 356
12.7. Artificial Neural Networks 357
12.8. Contextual Classification 359
12.9. Object-Oriented Classification 360
12.10. Iterative Guided Spectral Class Rejection 361
12.11. Summary 362
Review Questions 362
References 363

13. Field Data **367**
13.1. Introduction 367
13.2. Kinds of Field Data 367
13.3. Nominal Data 368
13.4. Documentation of Nominal Data 369
13.5. Biophysical Data 369
13.6. Field Radiometry 371
13.7. Aerial Data Collection 374
13.8. Locational Information 378
13.9. Using Locational Information 382
13.10. Ground Photography 382
13.11. Geographic Sampling 383
13.12. Summary 388
Review Questions 388
References 389

14. Accuracy Assessment **392**
14.1. Definition and Significance 392
14.2. Sources of Classification Error 394
14.3. Error Characteristics 395
14.4. Measurement of Map Accuracy 395
14.5. Interpretation of the Error Matrix 403
14.6. Summary 409
Review Questions 409
References 410

15. Hyperspectral Remote Sensing **413**
15.1. Introduction 413
15.2. Spectroscopy 413
15.3. Hyperspectral Remote Sensing 414
15.4. The Airborne Visible/Infrared Imaging Spectrometer 414
15.5. The Image Cube 416
15.6. Spectral Libraries 416
15.7. Spectral Matching 417
15.8. Spectral Mixing Analysis 418

15.9. Spectral Angle Mapping 421
15.10. Analyses 421
15.11. Summary 422
Review Questions 422
References 424

PART IV. APPLICATIONS

16. Remote Sensing and Geographic Information Systems **427**
16.1. Introduction 427
16.2. GIS Software 429
16.3. Basic Data Structures 432
16.4. Relationships between Remotely Sensed Data and GIS 436
16.5. Contributions of GIS to Remote Sensing 437
16.6. Contributions of Remote Sensing to GIS 438
16.7. National Center for Geographic Information and Analysis 441
16.8. Mobile GIS 442
16.9. Web-Based GIS 443
16.10. Summary 443
Review Questions 444
References 445

17. Plant Sciences **447**
17.1. Introduction 447
17.2. Structure of the Leaf 451
17.3. Spectral Behavior of the Living Leaf 453
17.4. Forestry 457
17.5. Agriculture 462
17.6. Vegetation Indices 465
17.7. Applications of Vegetation Indices 467
17.8. Phenology 467
17.9. Advanced Very-High-Resolution Radiometer 469
17.10. Broad-Scale Phenological Survey 472
17.11. Separating Soil Reflectance from Vegetation Reflectance 474
17.12. Tasseled Cap Transformation 476
17.13. Foliar Chemistry 478
17.14. Lidar Data for Forest Inventory and Structure 480
17.15. Precision Agriculture 481
17.16. Remote Sensing for Plant Pathology 482
17.17. Summary 486
Review Questions 486
References 487

18. Earth Sciences **493**
18.1. Introduction 493
18.2. Photogeology 494

18.3. Drainage Patterns 497
18.4. Lineaments 499
18.5. Geobotany 504
18.6. Direct Multispectral Observation of Rocks and Minerals 507
18.7. Photoclinometry 508
18.8. Band Ratios 511
18.9. Soil and Landscape Mapping 513
18.10. Integrated Terrain Units 517
18.11. Wetlands Inventory 518
18.12. Radar Imagery for Exploration 518
18.13. Summary 519
Review Questions 520
References 521

19. Hydrospheric Sciences **525**
19.1. Introduction 525
19.2. Spectral Characteristics of Water Bodies 526
19.3. Spectral Changes as Water Depth Increases 529
19.4. Location and Extent of Water Bodies 530
19.5. Roughness of the Water Surface 532
19.6. Bathymetry 534
19.7. Landsat Chromaticity Diagram 540
19.8. Drainage Basin Hydrology 543
19.9. Evapotranspiration 545
19.10. Manual Interpretation 547
19.11. Sea Surface Temperature 553
19.12. The Marine Food Chain 554
19.13. Summary 554
Review Questions 555
References 555

20. Land Use and Land Cover **559**
20.1. Introduction 559
20.2. Aerial Imagery for Land-Use Information 560
20.3. Land-Use Classification 561
20.4. Visual Interpretation of Land Use and Land Cover 562
20.5. Land-Use Change by Visual Interpretation 570
20.6. Historical Land-Cover Interpretation for Environmental Analysis 571
20.7. Other Land-Use Classification Systems 573
20.8. Land-Cover Mapping by Image Classification 575
20.9. Digital Compilation of Land-Use Change 577
20.10. Broad-Scale Land-Cover Studies 579
20.11. Sources of Compiled Land-Use Data 580
20.12. Summary 581
Review Questions 584
References 584

21. Global Remote Sensing **587**
21.1. Introduction 587
21.2. Biogeochemical Cycles 587
21.3. Advanced Very-High-Resolution Radiometer 593
21.4. Earth Observing System 594
21.5. Earth Observing System Instruments 595
21.6. Earth Observing System Bus 601
21.7. Earth Observing System Data and Information System 602
21.8. Long-Term Environmental Research Sites 603
21.9. Earth Explorer 604
21.10. Summary 605
Review Questions 605
References 606

Conclusion: The Outlook for the Field of Remote Sensing **608**

Index **611**

About the Author **626**

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