



CONTENTS

1 Concepts and Foundations of Remote Sensing 1

- 1.1** Introduction 1
- 1.2** Energy Sources and Radiation Principles 4
- 1.3** Energy Interactions in the Atmosphere 9
- 1.4** Energy Interactions with Earth Surface Features 12
- 1.5** Data Acquisition and Interpretation 30
- 1.6** Reference Data 38
- 1.7** The Global Positioning System 42
- 1.8** Characteristics of Remote Sensing Systems 45

- 1.9** Successful Application of Remote Sensing 48
- 1.10** Geographic Information Systems 51
- 1.11** Organization of the Book 59
 - Works Cited 60

2 Elements of Photographic Systems 61

- 2.1** Introduction 61
- 2.2** Early History of Aerial Photography 62
- 2.3** Photographic Basics 64
- 2.4** Film Photography 76
- 2.5** Digital Photography 96

- 2.6 Aerial Cameras 99
- 2.7 Spatial Resolution of Camera Systems 110
- 2.8 Aerial Videography 116
- 2.9 Multiband Imaging 120
- 2.10 Conclusion 121
- Works Cited 121

3

Basic Principles of Photogrammetry 123

- 3.1 Introduction 123
- 3.2 Basic Geometric Characteristics of Aerial Photographs 126
- 3.3 Photographic Scale 134
- 3.4 Ground Coverage of Aerial Photographs 140
- 3.5 Area Measurement 140
- 3.6 Relief Displacement of Vertical Features 146
- 3.7 Image Parallax 153
- 3.8 Ground Control for Aerial Photography 164
- 3.9 Production of Maps and Orthophotos 165
- 3.10 Flight Planning 181
- 3.11 Conclusion 188
- Works Cited 188

4

Introduction to Visual Image Interpretation 189

- 4.1 Introduction 189
- 4.2 Fundamentals of Visual Image Interpretation 190

- 4.3 Basic Visual Image Interpretation Equipment 207
- 4.4 Land Use/Land Cover Mapping 212
- 4.5 Geologic and Soil Mapping 223
- 4.6 Agricultural Applications 233
- 4.7 Forestry Applications 240
- 4.8 Rangeland Applications 250
- 4.9 Water Resource Applications 251
- 4.10 Urban and Regional Planning Applications 259
- 4.11 Wetland Mapping 269
- 4.12 Wildlife Ecology Applications 276
- 4.13 Archaeological Applications 281
- 4.14 Environmental Assessment 286
- 4.15 Natural Disaster Assessment 290
- 4.16 Principles of Landform Identification and Evaluation 302
- Works Cited 323

5

Multispectral, Thermal, and Hyperspectral Sensing 325

- 5.1 Introduction 325
- 5.2 Across-Track Scanning 326
- 5.3 Along-Track Scanning 332
- 5.4 Example Across-Track Multispectral Scanner and Imagery 334
- 5.5 Example Along-Track Multispectral Scanner and Imagery 338
- 5.6 Geometric Characteristics of Across-Track Scanner Imagery 340
- 5.7 Geometric Characteristics of Along-Track Scanner Imagery 350
- 5.8 Thermal Scanning 352
- 5.9 Thermal Radiation Principles 354

- 5.10 Interpreting Thermal Scanner Imagery 364
- 5.11 Radiometric Calibration of Thermal Scanners 375
- 5.12 Temperature Mapping with Thermal Scanner Data 378
- 5.13 FLIR Systems 379
- 5.14 Hyperspectral Sensing 380
- 5.15 Conclusion 391
- Works Cited 391

6 Earth Resource Satellites Operating in the Optical Spectrum 392

- 6.1 Introduction 392
- 6.2 Early History of Space Imaging 397
- 6.3 Landsat Satellite Program Overview 399
- 6.4 Landsat-1, -2, and -3 402
- 6.5 Landsat-4 and -5 406
- 6.6 Landsat-6 Planned Mission 414
- 6.7 Landsat-7 414
- 6.8 Landsat Image Examples 419
- 6.9 Landsat Data Continuity Mission 429
- 6.10 Long-Term Future of the Landsat Program and the Global Earth Observation System of Systems 431
- 6.11 SPOT Satellite Program 432
- 6.12 SPOT-1, -2, and -3 432
- 6.13 SPOT-4 438
- 6.14 SPOT-5 440
- 6.15 SPOT Image Examples 442
- 6.16 Other Earth Resource Satellites 446
- 6.17 Meteorological Satellites Frequently Applied to Earth Surface Feature Observation 462

- 6.18 Ocean Monitoring Satellites 469
- 6.19 Earth Observing System 471
- 6.20 Space Station Remote Sensing 480
- Works Cited 481

7 Digital Image Interpretation and Analysis 482

- 7.1 Introduction 482
- 7.2 Image Rectification and Restoration 485
- 7.3 Image Enhancement 499
- 7.4 Contrast Manipulation 500
- 7.5 Spatial Feature Manipulation 509
- 7.6 Multi-Image Manipulation 523
- 7.7 Image Classification 545
- 7.8 Supervised Classification 547
- 7.9 The Classification Stage 550
- 7.10 The Training Stage 557
- 7.11 Unsupervised Classification 568
- 7.12 Hybrid Classification 572
- 7.13 Classification of Mixed Pixels 574
- 7.14 The Output Stage 578
- 7.15 Postclassification Smoothing 580
- 7.16 Object-Oriented Classification 581
- 7.17 Classification Accuracy Assessment 585
- 7.18 Data Merging and GIS Integration 592
- 7.19 Hyperspectral Image Analysis 610
- 7.20 Biophysical Modeling 615
- 7.21 Scale Effects 617
- 7.22 Image Transmission and Compression 621
- 7.23 Conclusion 623
- Works Cited 623

8 Microwave and Lidar Sensing 626

- 8.1** Introduction 626
- 8.2** Radar Development 627
- 8.3** Side-Looking Radar System
Operation 630
- 8.4** Synthetic Aperture Radar 638
- 8.5** Geometric Characteristics of Radar
Imagery 641
- 8.6** Transmission Characteristics of Radar
Signals 648
- 8.7** Other Radar Image
Characteristics 653
- 8.8** Radar Image Interpretation 658
- 8.9** Interferometric Radar 678
- 8.10** Radar Remote Sensing from
Space 684
- 8.11** Seasat-1 686
- 8.12** Shuttle Imaging Radar 687
- 8.13** Almaz-1 693
- 8.14** ERS-1 and ERS-2 694
- 8.15** Envisat 696
- 8.16** JERS-1 697
- 8.17** ALOS 699
- 8.18** Radarsat 700
- 8.19** High Resolution Spaceborne Radar
Systems 704
- 8.20** Shuttle Radar Topography
Mission 705
- 8.21** Spaceborne Radar System
Summary 708
- 8.22** Passive Microwave Sensing 709
- 8.23** Lidar 714
Works Cited 726

Appendix A Radiometric Concepts, Terminology, and Units 727

- Geometric Characteristics of Radiation
Measurement 727
- Radiometric Terminology and
Units 729

Appendix B Remote Sensing Data and Information Resources 732

- Sources of Remote Sensing Data and
Information 732
- Remote Sensing Periodicals 734
- Remote Sensing Glossaries 734
- Online Remote Sensing Courses and
Tutorials 735

Appendix C Sample Coordinate Transformation and Resampling Procedures 736

- Two-Dimensional Affine Coordinate
Transformation 736
- Resampling Procedures 737

Appendix D Radar Signal Concepts, Terminology, and Units 741

- Signal Power and Radar Cross
Section 741
- Complex Amplitude of Radar
Signals 742

Index 746
