ENCYCLOPEDIA of REMOTE SENSING
Encyclopedia of Earth Sciences Series

ENCYCLOPEDIA OF REMOTE SENSING

Volume Editor
Eni G. Njoku is a Senior Research Scientist at the Jet Propulsion Laboratory, California Institute of Technology, Pasadena, California, USA. He has a B.A. from the University of Cambridge, and S.M. and Ph.D. from the Massachusetts Institute of Technology. His research focuses on spaceborne microwave sensing with application to land surface hydrology and the global water cycle. Amongst his awards are the NASA Exceptional Service Medal (1985) and Fellow of the Institute of Electrical and Electronics Engineers (1995).

Section Editors
Michael J. Abrams
Jet Propulsion Laboratory
California Institute of Technology
Pasadena, CA 91109
USA

Ghassem R. Asrar
World Climate Research Programme
World Meteorological Organization
1211 Geneva
Switzerland

Frank S. Marzano
Department of Information Engineering
Sapienza University of Rome
00184 Rome, Italy
and Centre of Excellence CETEMPS
University of L’Aquila
67100 L’Aquila
Italy

Peter J. Minnett
Meteorology and Physical Oceanography
Rosenstiel School of Marine and Atmospheric Science
University of Miami
Miami, FL 33149
USA

Vincent V. Salomonson
Department of Geography
University of Utah
Salt Lake City, UT 84112
USA

Vernon H. Singhroy
Canada Centre for Remote Sensing
Ottawa
Ontario K1A 0Y7
Canada

F. Joseph Turk
Jet Propulsion Laboratory
California Institute of Technology
Pasadena, CA 91109
USA

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About the Series Editor
Professor Charles W. Finkl has edited and/or contributed to more than eight volumes in the Encyclopedia of Earth Sciences Series. For the past 25 years he has been the Executive Director of the Coastal Education & Research Foundation and Editor-in-Chief of the international Journal of Coastal Research. In addition to these duties, he is Professor at Florida Atlantic University in Boca Raton, Florida, USA. He is a graduate of the University of Western Australia (Perth) and previously worked for a wholly owned Australian subsidiary of the International Nickel Company of Canada (INCO). During his career, he acquired field experience in Australia; the Caribbean; South America; SW Pacific islands; southern Africa; Western Europe; and the Pacific Northwest, Midwest, and Southeast USA.

Founding Series Editor
Professor Rhodes W. Fairbridge (deceased) has edited more than 24 Encyclopedias in the Earth Sciences Series. During his career he has worked as a petroleum geologist in the Middle East, been a WW II intelligence officer in the SW Pacific and led expeditions to the Sahara, Arctic Canada, Arctic Scandinavia, Brazil and New Guinea. He was Emeritus Professor of Geology at Columbia University and was affiliated with the Goddard Institute for Space Studies.
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edited by

ENI G. NJOKU
Jet Propulsion Laboratory
California Institute of Technology
Pasadena, California
USA
## Contents

<table>
<thead>
<tr>
<th>Chapter</th>
<th>Title</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Contributors</td>
<td>xi</td>
</tr>
<tr>
<td></td>
<td>Preface</td>
<td>xxiii</td>
</tr>
<tr>
<td></td>
<td>Acknowledgments</td>
<td>xxv</td>
</tr>
<tr>
<td></td>
<td>Acoustic Radiation</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Acoustic Tomography, Ocean</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>Acoustic Waves, Propagation</td>
<td>11</td>
</tr>
<tr>
<td></td>
<td>Acoustic Waves, Scattering</td>
<td>13</td>
</tr>
<tr>
<td></td>
<td>Aerosols</td>
<td>16</td>
</tr>
<tr>
<td></td>
<td>Agricultural Expansion and Abandonment</td>
<td>20</td>
</tr>
<tr>
<td></td>
<td>Agriculture and Remote Sensing</td>
<td>22</td>
</tr>
<tr>
<td></td>
<td>Air Pollution</td>
<td>32</td>
</tr>
<tr>
<td></td>
<td>Atmospheric General Circulation Models</td>
<td>35</td>
</tr>
<tr>
<td></td>
<td>Calibration and Validation</td>
<td>39</td>
</tr>
<tr>
<td></td>
<td>Calibration, Microwave Radiometers</td>
<td>46</td>
</tr>
<tr>
<td></td>
<td>Calibration, Optical/Infrared Passive Sensors</td>
<td>47</td>
</tr>
<tr>
<td></td>
<td>Calibration, Synthetic Aperture Radars</td>
<td>51</td>
</tr>
<tr>
<td></td>
<td>Climate Data Records</td>
<td>58</td>
</tr>
<tr>
<td></td>
<td>Climate Monitoring and Prediction</td>
<td>58</td>
</tr>
<tr>
<td></td>
<td>Cloud Liquid Water</td>
<td>68</td>
</tr>
<tr>
<td></td>
<td>Cloud Properties</td>
<td>70</td>
</tr>
<tr>
<td></td>
<td>Coastal Ecosystems</td>
<td>73</td>
</tr>
<tr>
<td></td>
<td>Commercial Remote Sensing</td>
<td>78</td>
</tr>
<tr>
<td></td>
<td>Cosmic-Ray Hydrometeorology</td>
<td>83</td>
</tr>
<tr>
<td></td>
<td>Cost Benefit Assessment</td>
<td>86</td>
</tr>
<tr>
<td></td>
<td>Crop Stress</td>
<td>88</td>
</tr>
<tr>
<td></td>
<td>Cryosphere and Polar Region Observing System</td>
<td>91</td>
</tr>
<tr>
<td>Topic</td>
<td>Page</td>
<td></td>
</tr>
<tr>
<td>-------</td>
<td>------</td>
<td></td>
</tr>
<tr>
<td>Cryosphere, Climate Change Effects&lt;br&gt;Aixue Hu</td>
<td>98</td>
<td></td>
</tr>
<tr>
<td>Cryosphere, Climate Change Feedbacks&lt;br&gt;Peter J. Minnett</td>
<td>101</td>
<td></td>
</tr>
<tr>
<td>Cryosphere, Measurements and Applications&lt;br&gt;Roger Barry</td>
<td>104</td>
<td></td>
</tr>
<tr>
<td>Data Access&lt;br&gt;Ron Weaver</td>
<td>119</td>
<td></td>
</tr>
<tr>
<td>Data Archival and Distribution&lt;br&gt;Mark A. Parsons</td>
<td>121</td>
<td></td>
</tr>
<tr>
<td>Data Archives and Repositories&lt;br&gt;Ruth Duerr</td>
<td>127</td>
<td></td>
</tr>
<tr>
<td>Data Assimilation&lt;br&gt;Dennis McLaughlin</td>
<td>131</td>
<td></td>
</tr>
<tr>
<td>Data Policies&lt;br&gt;Ray Harris</td>
<td>134</td>
<td></td>
</tr>
<tr>
<td>Data Processing, SAR Sensors&lt;br&gt;Jakob van Zyl</td>
<td>136</td>
<td></td>
</tr>
<tr>
<td>Decision Fusion, Classification of Multisource Data&lt;br&gt;Björn Waske and Jón Atli Benediktsson</td>
<td>140</td>
<td></td>
</tr>
<tr>
<td>Earth Radiation Budget, Top-of-Atmosphere Radiation&lt;br&gt;Bing Lin</td>
<td>145</td>
<td></td>
</tr>
<tr>
<td>Earth System Models&lt;br&gt;Andrea Donnellan</td>
<td>146</td>
<td></td>
</tr>
<tr>
<td>Electromagnetic Theory and Wave Propagation&lt;br&gt;Yang Du</td>
<td>150</td>
<td></td>
</tr>
<tr>
<td>Emerging Applications&lt;br&gt;William Gail</td>
<td>159</td>
<td></td>
</tr>
<tr>
<td>Emerging Technologies&lt;br&gt;Jason Hyon</td>
<td>162</td>
<td></td>
</tr>
<tr>
<td>Emerging Technologies, Free-Space Optical Communications&lt;br&gt;Hamid Hemmati</td>
<td>163</td>
<td></td>
</tr>
<tr>
<td>Emerging Technologies, Lidar&lt;br&gt;David M. Tratt</td>
<td>177</td>
<td></td>
</tr>
<tr>
<td>Emerging Technologies, Radar&lt;br&gt;Alina Moussessian</td>
<td>185</td>
<td></td>
</tr>
<tr>
<td>Emerging Technologies, Radiometer&lt;br&gt;Todd Gaier</td>
<td>186</td>
<td></td>
</tr>
<tr>
<td>Emerging Technologies, Sensor Web&lt;br&gt;Mahta Moghaddam, Agnelo Silva and Mingyan Liu</td>
<td>190</td>
<td></td>
</tr>
<tr>
<td>Environmental Treaties&lt;br&gt;Alexander de Sherbinin</td>
<td>196</td>
<td></td>
</tr>
<tr>
<td>Fields and Radiation&lt;br&gt;Frank S. Marzano</td>
<td>201</td>
<td></td>
</tr>
<tr>
<td>Fisheries&lt;br&gt;Cara Wilson</td>
<td>202</td>
<td></td>
</tr>
<tr>
<td>Forestry&lt;br&gt;Dar Roberts</td>
<td>210</td>
<td></td>
</tr>
<tr>
<td>Gamma and X-Radiation&lt;br&gt;Enrico Costa and Fabio Muleri</td>
<td>219</td>
<td></td>
</tr>
<tr>
<td>Geomorphology&lt;br&gt;David Pieri</td>
<td>237</td>
<td></td>
</tr>
<tr>
<td>Geophysical Retrieval, Forward Models in Remote Sensing&lt;br&gt;Eugene Ustinov</td>
<td>241</td>
<td></td>
</tr>
<tr>
<td>Geophysical Retrieval, Inverse Problems in Remote Sensing&lt;br&gt;Eugene Ustinov</td>
<td>247</td>
<td></td>
</tr>
<tr>
<td>Geophysical Retrieval, Overview&lt;br&gt;Eugene Ustinov</td>
<td>251</td>
<td></td>
</tr>
<tr>
<td>Global Climate Observing System&lt;br&gt;Jean-Louis Fellous</td>
<td>254</td>
<td></td>
</tr>
<tr>
<td>Global Earth Observation System of Systems (GEOSS)&lt;br&gt;Steffen Fritz</td>
<td>257</td>
<td></td>
</tr>
<tr>
<td>Global Land Observing System&lt;br&gt;Johannes A. Dolman</td>
<td>261</td>
<td></td>
</tr>
<tr>
<td>Global Programs, Operational Systems&lt;br&gt;Mary Kicza</td>
<td>263</td>
<td></td>
</tr>
<tr>
<td>GPS, Occultation Systems&lt;br&gt;Chi O. Ao</td>
<td>264</td>
<td></td>
</tr>
<tr>
<td>Title</td>
<td>Page</td>
<td>Authors</td>
</tr>
<tr>
<td>----------------------------------------------------------------------</td>
<td>------</td>
<td>---------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Ice Sheets and Ice Volume</td>
<td>269</td>
<td>Robert Thomas</td>
</tr>
<tr>
<td>Icebergs</td>
<td>281</td>
<td>Donald L. Murphy</td>
</tr>
<tr>
<td>International Collaboration</td>
<td>284</td>
<td>Lisa Robock Shaffer</td>
</tr>
<tr>
<td>Ionospheric Effects on the Propagation of Electromagnetic Waves</td>
<td>286</td>
<td>Attila Komjathy</td>
</tr>
<tr>
<td>Irrigation Management</td>
<td>291</td>
<td>Steven R. Evett, Paul D. Colaizzi, Susan A. O’Shaughnessy, Douglas J. Hunsaker and Robert G. Evans</td>
</tr>
<tr>
<td>Land Surface Emissivity</td>
<td>303</td>
<td>Alan Gillespie</td>
</tr>
<tr>
<td>Land Surface Roughness</td>
<td>311</td>
<td>Thomas Farr</td>
</tr>
<tr>
<td>Land Surface Temperature</td>
<td>314</td>
<td>Alan Gillespie</td>
</tr>
<tr>
<td>Land Surface Topography</td>
<td>320</td>
<td>G. Bryan Bailey</td>
</tr>
<tr>
<td>Land-Atmosphere Interactions, Evapotranspiration</td>
<td>325</td>
<td>Joshua B. Fisher</td>
</tr>
<tr>
<td>Landslides</td>
<td>328</td>
<td>Vernon H. Singhroy</td>
</tr>
<tr>
<td>Law of Remote Sensing</td>
<td>332</td>
<td>Joanne Irene Gabrynowicz</td>
</tr>
<tr>
<td>Lidar Systems</td>
<td>334</td>
<td>Robert Menzies</td>
</tr>
<tr>
<td>Lightning</td>
<td>339</td>
<td>Rachel I. Albrecht, Daniel J. Cecil and Steven J. Goodman</td>
</tr>
<tr>
<td>Limb Sounding, Atmospheric</td>
<td>344</td>
<td>Nathaniel Livesey</td>
</tr>
<tr>
<td>Madden-Julian Oscillation (MJO)</td>
<td>349</td>
<td>Baijun Tian and Duane Waliser</td>
</tr>
<tr>
<td>Magnetic Field</td>
<td>358</td>
<td>Nils Olsen</td>
</tr>
<tr>
<td>Media, Electromagnetic Characteristics</td>
<td>362</td>
<td>Yang Du</td>
</tr>
<tr>
<td>Microwave Dielectric Properties of Materials</td>
<td>364</td>
<td>Martti Hallikainen</td>
</tr>
<tr>
<td>Microwave Horn Antennas</td>
<td>375</td>
<td>Yahya Rahmat-Samii</td>
</tr>
<tr>
<td>Microwave Radiometers</td>
<td>382</td>
<td>Niels Skou</td>
</tr>
<tr>
<td>Microwave Radiometers, Conventional</td>
<td>386</td>
<td>Niels Skou</td>
</tr>
<tr>
<td>Microwave Radiometers, Correlation</td>
<td>389</td>
<td>Christopher Ruf</td>
</tr>
<tr>
<td>Microwave Radiometers, Interferometers</td>
<td>390</td>
<td>Manuel Martin-Neira</td>
</tr>
<tr>
<td>Microwave Radiometers, Polarimeters</td>
<td>395</td>
<td>David Kunkee</td>
</tr>
<tr>
<td>Microwave Subsurface Propagation and Scattering</td>
<td>398</td>
<td>Alexander Yarovoy</td>
</tr>
<tr>
<td>Microwave Surface Scattering and Emission</td>
<td>403</td>
<td>David R. Lyzenga</td>
</tr>
<tr>
<td>Mission Costs of Earth-Observing Satellites</td>
<td>405</td>
<td>Randall Friedl and Stacey Boland</td>
</tr>
<tr>
<td>Mission Operations, Science Applications/Requirements</td>
<td>407</td>
<td>David L. Glackin</td>
</tr>
<tr>
<td>Observational Platforms, Aircraft, and UAVs</td>
<td>409</td>
<td>Jeffrey Myers</td>
</tr>
<tr>
<td>Observational Systems, Satellite</td>
<td>412</td>
<td>David L. Glackin</td>
</tr>
<tr>
<td>Ocean Applications of Interferometric SAR</td>
<td>426</td>
<td>Roland Romeiser</td>
</tr>
<tr>
<td>Ocean Data Telemetry</td>
<td>429</td>
<td>Michael R. Prior-Jones</td>
</tr>
<tr>
<td>Ocean Internal Waves</td>
<td>433</td>
<td>Werner Alpers</td>
</tr>
<tr>
<td>Ocean Measurements and Applications, Ocean Color</td>
<td>437</td>
<td>Samantha Lavender</td>
</tr>
<tr>
<td>Ocean Modeling and Data Assimilation</td>
<td>446</td>
<td>Detlef Stammer</td>
</tr>
<tr>
<td>Ocean Surface Topography</td>
<td>455</td>
<td>Lee-Lueng Fu</td>
</tr>
<tr>
<td>Title</td>
<td>Page</td>
<td>Authors</td>
</tr>
<tr>
<td>------------------------------------------------------------</td>
<td>------</td>
<td>-------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Ocean Surface Velocity</td>
<td>461</td>
<td>Bertrand Chapron, Johnny Johannessen and Fabrice Collard</td>
</tr>
<tr>
<td>Ocean, Measurements and Applications</td>
<td>469</td>
<td>Ian Robinson</td>
</tr>
<tr>
<td>Ocean-Atmosphere Water Flux and Evaporation</td>
<td>480</td>
<td>W. Timothy Liu and Xiaosu Xie</td>
</tr>
<tr>
<td>Operational Transition</td>
<td>489</td>
<td>Richard Anthes</td>
</tr>
<tr>
<td>Optical/Infrared, Atmospheric Absorption/Transmission, and Media Spectral Properties</td>
<td>492</td>
<td>Gian Luigi Liberti</td>
</tr>
<tr>
<td>Optical/Infrared, Radiative Transfer</td>
<td>495</td>
<td>Knut Stamnes</td>
</tr>
<tr>
<td>Optical/Infrared, Scattering by Aerosols and Hydrometeors</td>
<td>498</td>
<td>Gian Luigi Liberti</td>
</tr>
<tr>
<td>Pattern Recognition and Classification</td>
<td>503</td>
<td>Björn Wäske and Jón Atli Benediktsson</td>
</tr>
<tr>
<td>Polar Ice Dynamics</td>
<td>509</td>
<td>James Maslanik</td>
</tr>
<tr>
<td>Polar Ocean Navigation</td>
<td>512</td>
<td>Lawson Brigham</td>
</tr>
<tr>
<td>Policies and Economics</td>
<td>515</td>
<td>Roberta Balstad</td>
</tr>
<tr>
<td>Precision Agriculture</td>
<td>515</td>
<td>Kelly Thorp</td>
</tr>
<tr>
<td>Processing Levels</td>
<td>517</td>
<td>Ron Weaver</td>
</tr>
<tr>
<td>Public-Private Partnerships</td>
<td>520</td>
<td>William Gail</td>
</tr>
<tr>
<td>Radar, Altimeters</td>
<td>525</td>
<td>Keith Raney</td>
</tr>
<tr>
<td>Radar, Scatterometers</td>
<td>532</td>
<td>David Long</td>
</tr>
<tr>
<td>Radar, Synthetic Aperture</td>
<td>536</td>
<td>Keith Raney</td>
</tr>
<tr>
<td>Radars</td>
<td>547</td>
<td>Keith Raney</td>
</tr>
<tr>
<td>Radiation (Natural) Within the Earth’s Environment</td>
<td>558</td>
<td>Anthony England</td>
</tr>
<tr>
<td>Radiation Sources (Natural) and Characteristics</td>
<td>574</td>
<td>Anthony England</td>
</tr>
<tr>
<td>Radiation, Electromagnetic</td>
<td>576</td>
<td>Frank S. Marzano</td>
</tr>
<tr>
<td>Radiation, Galactic, and Cosmic Background</td>
<td>581</td>
<td>David M. Le Vine</td>
</tr>
<tr>
<td>Radiation, Multiple Scattering</td>
<td>585</td>
<td>Frank S. Marzano</td>
</tr>
<tr>
<td>Radiation, Polarization, and Coherence</td>
<td>588</td>
<td>Yang Du</td>
</tr>
<tr>
<td>Radiation, Solar and Lunar</td>
<td>591</td>
<td>David M. Le Vine</td>
</tr>
<tr>
<td>Radiation, Volume Scattering</td>
<td>595</td>
<td>Leung Tsang and Kung-Hau Ding</td>
</tr>
<tr>
<td>Radiative Transfer, Solution Techniques</td>
<td>606</td>
<td>Rodolfo Guzzo</td>
</tr>
<tr>
<td>Radiative Transfer, Theory</td>
<td>624</td>
<td>Frank S. Marzano</td>
</tr>
<tr>
<td>Radio-Frequency Interference (RFI) in Passive Microwave Sensing</td>
<td>634</td>
<td>David Kunkee</td>
</tr>
<tr>
<td>Rainfall</td>
<td>640</td>
<td>Ralph Ferraro</td>
</tr>
<tr>
<td>Rangelands and Grazing</td>
<td>653</td>
<td>Hunt E. Raymond, Jr.</td>
</tr>
<tr>
<td>Reflected Solar Radiation Sensors, Multiangle Imaging</td>
<td>658</td>
<td>David J. Diner</td>
</tr>
<tr>
<td>Reflected Solar Radiation Sensors, Polarimetric</td>
<td>663</td>
<td>David J. Diner</td>
</tr>
<tr>
<td>Reflector Antennas</td>
<td>668</td>
<td>Yahya Rahmat-Samii</td>
</tr>
<tr>
<td>Remote Sensing and Geologic Structure</td>
<td>681</td>
<td>Vernon H. Singhroy and Paul Lowman</td>
</tr>
<tr>
<td>Remote Sensing, Historical Perspective</td>
<td>684</td>
<td>Vincent V. Salomonson</td>
</tr>
<tr>
<td>Topic</td>
<td>Page</td>
<td>Authors</td>
</tr>
<tr>
<td>---------------------------------------------------------</td>
<td>------</td>
<td>------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Remote Sensing, Physics and Techniques</td>
<td>691</td>
<td>David L. Glackin</td>
</tr>
<tr>
<td>Resource Exploration</td>
<td>702</td>
<td>Fred A. Kruse and Sandra L. Perry</td>
</tr>
<tr>
<td>SAR-Based Bathymetry</td>
<td>719</td>
<td>Han Wensink and Werner Alpers</td>
</tr>
<tr>
<td>Sea Ice Albedo</td>
<td>722</td>
<td>Donald Perovich</td>
</tr>
<tr>
<td>Sea Ice Concentration and Extent</td>
<td>727</td>
<td>Josefino C. Comiso</td>
</tr>
<tr>
<td>Sea Level Rise</td>
<td>743</td>
<td>Josh Willis</td>
</tr>
<tr>
<td>Sea Surface Salinity</td>
<td>747</td>
<td>Gary Lagerloef</td>
</tr>
<tr>
<td>Sea Surface Temperature</td>
<td>754</td>
<td>Peter J. Minnett</td>
</tr>
<tr>
<td>Sea Surface Wind/Stress Vector</td>
<td>759</td>
<td>W. Timothy Liu and Xiaosu Xie</td>
</tr>
<tr>
<td>Severe Storms</td>
<td>767</td>
<td>Charles A. III Doswell</td>
</tr>
<tr>
<td>Snowfall</td>
<td>780</td>
<td>Ralf Bennartz</td>
</tr>
<tr>
<td>Soil Moisture</td>
<td>783</td>
<td>Yann Kerr</td>
</tr>
<tr>
<td>Soil Properties</td>
<td>788</td>
<td>Alfredo Huete</td>
</tr>
<tr>
<td>Solid Earth Mass Transport</td>
<td>791</td>
<td>Erik Ivins</td>
</tr>
<tr>
<td>Stratospheric Ozone</td>
<td>796</td>
<td>Michelle Santee</td>
</tr>
<tr>
<td>Subsidence</td>
<td>800</td>
<td>Stuart Marsh and Martin Culshaw</td>
</tr>
<tr>
<td>Surface Radiative Fluxes</td>
<td>806</td>
<td>Rachel T. Pinker</td>
</tr>
<tr>
<td>Surface Truth</td>
<td>815</td>
<td>Christopher Ruf</td>
</tr>
<tr>
<td>Surface Water</td>
<td>816</td>
<td>Michael Durand</td>
</tr>
<tr>
<td>Terrestrial Snow</td>
<td>691</td>
<td>Son V. Nghiem, Dorothy K. Hall, James L. Foster and Gregory Neumann</td>
</tr>
<tr>
<td>Thermal Radiation Sensors (Emitted)</td>
<td>702</td>
<td>Simon Hook</td>
</tr>
<tr>
<td>Trace Gases, Stratosphere, and Mesosphere</td>
<td>719</td>
<td>Nathaniel Livesey</td>
</tr>
<tr>
<td>Trace Gases, Troposphere - Detection from Space</td>
<td>722</td>
<td>Pieternel F. Levelt, J. P. Veefkind and K. F. Boersma</td>
</tr>
<tr>
<td>Trafficability of Desert Terrains</td>
<td>727</td>
<td>Charles Hibbitts</td>
</tr>
<tr>
<td>Tropospheric Winds</td>
<td>743</td>
<td>Chris Velden</td>
</tr>
<tr>
<td>Ultraviolet Remote Sensing</td>
<td>747</td>
<td>Arlin Krueger</td>
</tr>
<tr>
<td>Ultraviolet Sensors</td>
<td>754</td>
<td>Arlin Krueger</td>
</tr>
<tr>
<td>Urban Environments, Beijing Case Study</td>
<td>759</td>
<td>Son V. Nghiem, Alessandro Sorichetta, Christopher D. Elvidge, Christopher Small, Deborah Balk, Uwe Deichmann and Gregory Neumann</td>
</tr>
<tr>
<td>Urban Heat Island</td>
<td>767</td>
<td>Lela Prashad</td>
</tr>
<tr>
<td>Vegetation Indices</td>
<td>780</td>
<td>Alfredo Huete</td>
</tr>
<tr>
<td>Vegetation Phenology</td>
<td>783</td>
<td>John Kimball</td>
</tr>
<tr>
<td>Volcanism</td>
<td>788</td>
<td>Michael J. Abrams</td>
</tr>
<tr>
<td>Water and Energy Cycles</td>
<td>791</td>
<td>Taikan Oki and Pat J.-F. Yeh</td>
</tr>
<tr>
<td>Water Resources</td>
<td>796</td>
<td>Taikan Oki and Pat J.-F. Yeh</td>
</tr>
<tr>
<td>Water Vapor</td>
<td>800</td>
<td>Eric Fetzer</td>
</tr>
<tr>
<td>Weather Prediction</td>
<td>806</td>
<td>Peter Bauer</td>
</tr>
<tr>
<td>Wetlands</td>
<td>815</td>
<td>John Melack</td>
</tr>
<tr>
<td>Author Index</td>
<td>816</td>
<td></td>
</tr>
<tr>
<td>Subject Index</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Jón Atli Benediktsson  
Faculty of Electrical and Computer Engineering  
University of Iceland  
107 Reykjavik  
Iceland  
benedikt@hi.is

Ralf Bennartz  
Atmospheric and Oceanic Sciences Department  
University of Wisconsin-Madison  
Madison, WI 53706-1481  
USA  
bennartz@aos.wisc.edu

K. F. Boersma  
Koninklijk Nederlands Meteorologisch Instituut (KNMI)  
3732 OK, De Bilt  
The Netherlands  
and  
Technical University Eindhoven (TUE)  
5612 AZ, Eindhoven  
The Netherlands  
k.j.boersma@tu.nl

Stacey Boland  
Jet Propulsion Laboratory  
California Institute of Technology  
Pasadena, CA 91109  
USA

Lawson Brigham  
University of Alaska  
Fairbanks, AK 99775-5840  
USA  
lwb48@aol.com

Carol Bruegge  
Jet Propulsion Laboratory  
California Institute of Technology  
Pasadena, CA 91109  
USA  
carol.j.bruegge@jpl.nasa.gov

Daniel J. Cecil  
Marshall Space Flight Center (MSFC), National Aeronautics and Space Administration (NASA)  
Huntsville, AL 35805  
USA  
daniel.j.cecil@nasa.gov

Bertrand Chapron  
Satellite Oceanography Laboratory, IFREMER  
Plouzané 29280  
France  
bertrand.chapron@ifremer.fr

Paul D. Colaizzi  
USDA-ARS Conservation and Production Research Laboratory  
Bushland, TX 79012  
USA  
paul.colaizzi@ars.usda.gov

Fabrice Collard  
CLS, Division Radar  
Plouzané 29280  
France  
dr.fab@cls.fr

Andreas Colliander  
Jet Propulsion Laboratory  
California Institute of Technology  
Pasadena, CA 91109  
USA  
andreas.colliander@jpl.nasa.gov

Josefino C. Comiso  
Cryospheric Sciences Laboratory, Code 615  
Earth Sciences Division, NASA Goddard Space Flight Center  
Greenbelt, MD 20771  
USA  
josefino.c.comiso@nasa.gov

Steve Cooper  
Jet Propulsion Laboratory  
California Institute of Technology  
Pasadena, CA 91109  
USA

Enrico Costa  
Istituto di Astrofisica e Planetologia Spaziali, INAF  
00133 Rome  
Italy  
enrico.costa@iasf-roma.inaf.it

Martin Culshaw  
Honorary Research Associate, British Geological Survey, Keyworth  
Nottingham NG12 1AE  
UK  
and  
Honorary Visiting Professor, School of Civil Engineering, University of Birmingham, Edgbaston  
Birmingham B15 2TT  
UK

Alexander de Sherbinin  
Center for International Earth Science Information Network (CIESIN)  
Columbia University  
Palisades, NY 10964  
USA  
adesherbinin@ciesin.columbia.edu
Uwe Deichmann  
Development Research Group, The World Bank  
Washington, DC  
USA  
udeichmann@worldbank.org

Darin Desilets  
Hydroinnova LLC  
Albuquerque, NM 87106  
USA  
darin@hydroinnova.com

David J. Diner  
Jet Propulsion Laboratory  
California Institute of Technology  
Pasadena, CA 91109  
USA  
david.j.diner@jpl.nasa.gov

Kung-Hau Ding  
Air Force Research Laboratory  
Wright-Patterson AFB  
Dayton, OH 45433  
USA

Johannes A. Dolman  
Department of Earth Sciences  
VU University Amsterdam  
1081 Amsterdam  
The Netherlands  
han.dolman@vu.nl

Andrea Donnellan  
Science Division  
Jet Propulsion Laboratory  
California Institute of Technology  
Pasadena, CA 91109  
USA  
andrea.donnellan@jpl.nasa.gov

Charles A. III Doswell  
Doswell Scientific Consulting  
Norman, OK 73071  
USA  
cdoswell@earthlink.net

Mark Drinkwater  
Mission Science Division  
European Space Agency, ESA/ESTEC  
2201 AZ Noordwijk ZH  
The Netherlands  
mark.drinkwater@esa.int

Yang Du  
Zhejiang University  
310027 Hangzhou  
People’s Republic of China  
zjuydu03@zju.edu.cn

Ruth Duerr  
National Snow and Ice Data Center, CIRES 449 UCB,  
University of Colorado  
Boulder, CO 80309  
USA  
rduerr@nsidc.org

Michael Durand  
School of Earth Sciences  
The Ohio State University  
275 Mendenhall Laboratory  
Columbus, OH 43210  
USA  
durand.8@osu.edu

Brian Dushaw  
Applied Physics Laboratory  
University of Washington  
Seattle, WA 98105-6698  
USA  
dushaw@apl.washington.edu

Annmarie Eldering  
Jet Propulsion Laboratory  
California Institute of Technology  
Pasadena, CA 91109  
USA  
annmarie.eldering@jpl.nasa.gov

Christopher D. Elvidge  
Earth Observation Group, NOAA-NESDIS National  
Geophysical Data Center E/GC2  
Boulder, CO  
USA  
chris.elvidge@noaa.gov

Anthony England  
College of Engineering  
University of Michigan  
Ann Arbor, MI 48109  
USA  
england@umich.edu

Robert G. Evans  
USDA-ARS  
Sidney, MT 59270  
USA  
robert.evans@ars.usda.gov

Steven R. Evett  
USDA-ARS Conservation and Production Research  
Laboratory  
Bushland, TX 79012  
USA  
steve.evett@ars.usda.gov
Thomas Farr  
Jet Propulsion Laboratory  
California Institute of Technology  
Pasadena, CA 91109  
USA  
thomas.g.farr@jpl.nasa.gov

Jean-Louis Fellous  
Committee on Space Research (COSPAR) Secretariat  
c/o CNES-2, place Maurice Quentin  
75039 Paris  
France  
jean-louis.fellous@cosparhq.cnes.fr

Ralph Ferraro  
NOAA/NESDIS, ESSIC/CICS  
College Park, MD 20740  
USA  
ralph.r.ferraro@noaa.gov

Eric Fetzer  
Jet Propulsion Laboratory  
California Institute of Technology  
Pasadena, CA 91109  
USA  
eric.j.fetzer@jpl.nasa.gov

Joshua B. Fisher  
Jet Propulsion Laboratory  
California Institute of Technology  
Pasadena, CA 91109  
USA  
joshua.b.fisher@jpl.nasa.gov

James L. Foster  
Hydrological Sciences Laboratory, Code 617  
National Aeronautics and Space Administration  
Goddard Space Flight Center  
Greenbelt, MD  
USA  
james.l.foster@nasa.gov

Anthony Freeman  
Jet Propulsion Laboratory  
California Institute of Technology  
Pasadena, CA 91109  
USA  
anthony.freeman@jpl.nasa.gov

Randall Friedl  
Jet Propulsion Laboratory  
California Institute of Technology  
Pasadena, CA 91109  
USA  
randall.r.friedl@jpl.nasa.gov

Steffen Fritz  
International Institute for Applied Systems Analysis  
2361 Laxenburg  
Austria  
fritz@iiasa.ac.at

Lee-Lueng Fu  
Jet Propulsion Laboratory  
California Institute of Technology  
Pasadena, CA 91109  
USA  
llf@jpl.nasa.gov

Joanne Irene Gabrynowicz  
National Center for Remote Sensing, Air, and Space Law  
The University of Mississippi School of Law  
Mississippi, MS 38677-1848  
USA  
jgabryno@olemiss.edu

Todd Gaier  
Jet Propulsion Laboratory  
California Institute of Technology  
Pasadena, CA 91109  
USA  
todd.c.gaier@jpl.nasa.gov

William Gail  
Global Weather Corporation  
Boulder, CO 80303  
USA  
wb.gail@comcast.net

Alan Gillespie  
Department of Earth and Space Sciences  
University of Washington  
Seattle, WA 98195  
USA  
gillespie@ess.washington.edu

David L. Glackin  
Los Angeles, CA  
USA

Steven J. Goodman  
National Environmental Satellite, Data, and Information Service (NESDIS), National Oceanic and Atmospheric Administration (NOAA)  
Silver Spring, MD 20910  
USA  
steven.j.goodman@noaa.gov

Rodolfo Guzzi  
Agenzia Spaziale Italiana ASI  
00133 Roma  
Italy  
rodlfoguzzi@yahoo.it
CONTRIBUTORS

Dorothy K. Hall
Cryospheric Sciences Laboratory, Code 615
NASA/Goddard Space Flight Center
Greenbelt, MD 20771
USA
dorothy.k.hall@nasa.gov

Martti Hallikainen
Aalto University
00076 Aalto Espoo
Finland
martti.hallikainen@aalto.fi

Ray Harris
Department of Geography
University College London
London WC1E 6BT
UK
ray.harris@ucl.ac.uk

Jerry Hatfield
National Laboratory for Agriculture and the Environment
Ames, IA 50011
USA
jerry.hatfield@ars.usda.gov

Hamid Hemmati
Jet Propulsion Laboratory
California Institute of Technology
Pasadena, CA 91109
USA
hamid.hemmati@jpl.nasa.gov

Charles Hibbitts
Applied Physics Laboratory
Laurel, MD 20723
USA
karl.hibbitts@jhuapl.edu

Simon Hook
Jet Propulsion Laboratory
California Institute of Technology
Pasadena, CA 91109
USA
simon.j.hook@jpl.nasa.gov

Aixue Hu
Climate and Global Dynamics Division
National Center for Atmospheric Research
Boulder, CO 80305
USA
ahu@ucar.edu

Alfredo Huete
Plant Functional Biology and Climate Change Cluster
Faculty of Science
University of Technology
2007 Sydney, NSW
Australia
alfredo.huete@uts.edu.au

Douglas J. Hunsaker
USDA-ARS
Maricopa, AZ 85138
USA
doug.hunsaker@ars.usda.gov

E. Raymond Hunt, Jr.
USDA-ARS Hydrology and Remote Sensing Laboratory
Beltsville, MD 20705
USA
raymond.hunt@ars.usda.gov

Jason Hyon
Jet Propulsion Laboratory
California Institute of Technology
Pasadena, CA 91109
USA
jason.j.hyon@jpl.nasa.gov

Erik Ivins
Jet Propulsion Laboratory
California Institute of Technology
Pasadena, CA 91109
USA
erik.r.ivins@jpl.nasa.gov

Johnny Johannessen
Nansen Environmental and Remote Sensing Center
5006 Bergen
Norway
johnny.johannessen@nersc.no

Ralph Kahn
NASA Goddard Space Flight Center
Greenbelt, MD 20771
USA
ralph.kahn@nasa.gov

Yann Kerr
CNES/CESBIO
31401 Toulouse
France
yann.kerr@cesbio.cnrs.fr

Mary Kicza
National Oceanic and Atmospheric Administration (NOAA)
Washington, DC 20230
USA
nina.jackson@noaa.gov
CONTRIBUTORS

John Kimball  
Flathead Lake Biological Station  
University of Montana  
Polson, MT 59860-6815  
USA  
johnk@ntsg.umt.edu

Calvin Klatt  
Geodetic Survey Division  
Natural Resources Canada  
Ottawa, ON K1A 0E9  
Canada  
cklatt@nrcan.gc.ca

Attila Komjathy  
Jet Propulsion Laboratory  
California Institute of Technology  
Pasadena, CA 91109  
USA  
attila.komjathy@jpl.nasa.gov

Arlin Krueger  
Atmospheric Chemistry and Dynamics Laboratory  
(Code 614)  
NASA/Goddard Space Flight Center  
Greenbelt, MD 20771  
USA  
akrueger3@verizon.net

Fred A. Kruse  
Physics Department and Remote Sensing Center  
Naval Postgraduate School  
Monterey, CA 93943  
USA  
fakruse@nps.edu

David Kunkee  
The Aerospace Corporation  
Los Angeles, CA 90009  
USA  
david.b.kunkee@aero.org

Gary Lagerloef  
ESR  
Seattle, WA 98121  
USA  
lager@esr.org

Samantha Lavender  
Pixalytics Ltd  
Plymouth, Devon PL6 8BX  
UK  
slavender@pixalytics.com

David M. Le Vine  
Code 615, Cryospheric Sciences Branch  
NASA/Goddard Space Flight Center  
Greenbelt, MD 20771  
USA  
david.m.levine@nasa.gov

Matthew Lebsock  
Jet Propulsion Laboratory  
California Institute of Technology  
Pasadena, CA 91109  
USA  
matthew.d.lebsock@jpl.nasa.gov

Pieternel F. Levelt  
Koninklijk Nederlands Meteorologisch Instituut (KNMI)  
3730 AE De Bilt  
The Netherlands  
and  
Delft University of Technology  
5612 AE Eindhoven  
The Netherlands  
pieternel.levelt@knmi.nl

Gian Luigi Liberti  
CNR/ISAC  
00133 Rome  
Italy  
g.liberti@isac.cnr.it

Bing Lin  
NASA Langley Research Center, MS 420  
Hampton, VA 23681-2199  
USA  
bing.lin@nasa.gov

Mingyan Liu  
Electrical and Computer Engineering  
University of Michigan  
Ann Arbor, MI 48109  
USA

W. Timothy Liu  
Jet Propulsion Laboratory  
California Institute of Technology  
Pasadena, CA 91109  
USA  
w.t.liu@jpl.nasa.gov

Nathaniel Livesey  
Jet Propulsion Laboratory  
California Institute of Technology  
Pasadena, CA 91109  
USA  
nathaniel.j.livesey@jpl.nasa.gov
CONTRIBUTORS

David Long
Department of Electrical and Computer Engineering
BYU Center for Remote Sensing
Brigham Young University
Provo, UT 84602
USA
long@byu.edu

Paul Lowman
NASA Goddard, Code 698.0
Greenbelt, MD 20771
USA
paul.d.lowman@nasa.gov

David R. Lyzenga
College of Engineering, Naval Architecture and Marine Engineering
University of Michigan
Ann Arbor, MI 48109-2145
USA
lyzenga@umich.edu

Molly Macauley
Resources for the Future
Washington, DC 202-328-5043
USA
macauley@rff.org

Stuart Marsh
Nottingham Geospatial Institute
The University of Nottingham
Nottingham Geospatial Building, Triumph Road
Nottingham NG7 2TU
UK
ngi@nottingham.ac.uk

Manuel Martin-Neira
European Space Agency (ESA-ESTEC)
Keplerlaan 1
2200 Noordwijk
The Netherlands
manuel.martin-neira@esa.int

Frank S. Marzano
Department of Information Engineering
Sapienza University of Rome
00184 Rome
Italy
and
Centre of Excellence CETEMPS
University of L’Aquila
67100 L’Aquila
Italy
frank.marzano@uniroma1.it

James Maslanik
Department of Aerospace Engineering Sciences
University of Colorado, CCAR
Boulder, CO 80309
USA
jimmi@colorado.edu

Georgios Matheou
Jet Propulsion Laboratory
California Institute of Technology
Pasadena, CA 91109
USA
giorgios.matheou@jpl.nasa.gov

Dennis McLaughlin
Department of Civil and Environmental Engineering
Massachusetts Institute of Technology
Cambridge, MA 02139
USA
dennism@mit.edu

John Melack
Department of Ecology, Evolution and Marine Biology
University of California
Santa Barbara, CA 93106
USA
melack@lifesci.ucsb.edu

Robert Menzies
Jet Propulsion Laboratory
California Institute of Technology
Pasadena, CA 91109
USA
robert.t.menzies@jpl.nasa.gov

Peter J. Minnett
Rosenstiel School of Marine and Atmospheric Science
University of Miami
Miami, FL 33149
USA
pminnett@rsmas.miami.edu

Mahta Moghaddam
Electrical Engineering – Electrophysics
University of Southern California
Los Angeles, CA 0089
USA
mahta@usc.edu

Susan Moran
USDA ARS Southwest Watershed Research Center
Tuscon, AZ 85719
USA
susan.moran@ars.usda.gov
CONTRIBUTORS

Christopher Small
Lamont Doherty Earth Observatory
Marine Geology and Geophysics
Columbia University
Palisades, NY
USA
cs184@columbia.edu

Alessandro Sorichetta
Dipartimento di Scienze della Terra “A. Desio”
Università’ degli Studi di Milano
20122 Milan
Italy
alessandro.sorichetta@unimi.it

Detlef Stammer
Institut für Meereskunde, Zentrum für Marine und
Atmosphärische Wissenschaften
Universität Hamburg
20146 Hamburg
Germany
detlef.stammer@zmaw.de

Knut Stamnes
Stevens Institute of Technology, Castle Point on Hudson
Hoboken, NJ 07030-5991
USA
kstamnes@stevens.edu

Mark Taylor
Sandia National Laboratory
Albuquerque, New Mexico 91109
USA
mataylor@sandia.gov

Joao Teixeira
Jet Propulsion Laboratory
California Institute of Technology
Pasadena, CA 91109
USA
teixeira@jpl.nasa.gov

Robert Thomas
Sigma Space
66-400 Gorzow Wlkp
Poland
robert_thomas@hotmail.com

Kelly Thorp
USDA-ARS U.S. Arid-Land Agricultural Research
Center
Maricopa, AZ 85138
USA
kelly.thorp@ars.usda.gov

Baijun Tian
Jet Propulsion Laboratory
California Institute of Technology
Pasadena, CA 91109
USA
baijun.tian@jpl.nasa.gov

David M. Tratt
The Aerospace Corporation
Los Angeles, CA 90009-2957
USA
dtratt@aero.org

Leung Tsang
Paul Allen Center
Department of Electrical Engineering
University of Washington
Seattle, WA 98195-2500
USA
leung@ee.washington.edu

Eugene Ustinov
Jet Propulsion Laboratory
California Institute of Technology
Pasadena, CA 91109
USA
eugene.a.ustinov@jpl.nasa.gov

Jakob van Zyl
Jet Propulsion Laboratory
California Institute of Technology
Pasadena, CA 91109
USA
jakob.j.vanzyl@jpl.nasa.gov

J. P. Veefkind
Koninklijk Nederlands Meteorologisch Instituut (KNMI)
3732 GK, De Bilt
The Netherlands
and
Eindhoven University of Technology
5612 AE Eindhoven
The Netherlands
veefkind@knmi.n

Chris Velden
University of Wisconsin, CIMSS
Madison, WI 53706
USA
chrsv@ssec.wisc.edu

Duane Waliser
Jet Propulsion Laboratory
California Institute of Technology
Pasadena, CA 91109
USA
duane.e.waliser@jpl.nasa.gov
Björn Waske  
Institute of Geodesy and Geoinformation  
University of Bonn  
53115 Bonn  
Germany  
wf@ipb.uni-bonn.de

Ron Weaver  
National Snow and Ice Data Center, Cooperative Institute for Research in Environmental Sciences  
University of Colorado  
Boulder, CO 80309-0449  
USA  
weaverr@kryos.colorado.edu

Alain Weill  
Bur. Jussieu  
LATMOS, Laboratoire Atmosphere Milieux Observations Spatiales  
75005 Paris  
France  
alain.weill@latmos.ipsl.fr

Fuzhong Weng  
Center for Satellite Applications and Research (STAR)  
National Oceanic and Atmospheric Administration  
College Park, MD 20740  
USA  
fuzhong.weng@noaa.gov

Han Wensink  
ARGOSS BV  
8325ZH Vollenhove  
The Netherlands  
wensink@argoss.nl

Josh Willis  
Jet Propulsion Laboratory  
California Institute of Technology  
Pasadena, CA 91109  
USA  
joshua.k.willis@jpl.nasa.gov

Cara Wilson  
Southwest Fisheries Science Center  
NOAA/NMFS, Environmental Research Division  
Pacific Grove, CA 93950-2097  
USA  
cara.wilson@noaa.gov

Eric F. Wood  
Department of Civil and Environmental Engineering  
Princeton University  
Princeton, NJ 08544  
USA  
efwood@princeton.edu

Xiaosu Xie  
Jet Propulsion Laboratory  
California Institute of Technology  
Pasadena, CA 91109  
USA  
xiaosu.xie@jpl.nasa.gov

Xiaojun Yang  
Department of Geography  
Florida State University  
Tallahassee, FL 32306-2190  
USA  
xyang@fsu.edu

Alexander Yarovoy  
Delft University of Technology  
2628 CN Delft  
The Netherlands  
a.yarovoy@tudelft.nl

Pat J.-F. Yeh  
Department of Civil and Environmental Engineering  
National University of Singapore  
117576 Singapore  
Singapore  
ceeyehj@nus.edu.sg

Marek Zreda  
Department of Hydrology and Water Resources  
University of Arizona  
Tucson, AZ 85721  
USA  
marek@hwr.arizona.edu
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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