Contents

Foreword xiii

Acronyms xvii

Introduction xli

Chapter 1. Optical Remote Sensing in Urban Environments 1
Xavier BRIOTTET, Nesrine CHEHATA, Rosa OLTRA-CARRIO, Arnaud LE BRIS and Christiane WEBER

1.1. Introduction 1
1.1.1. The urban system 1
1.1.2. The urban environment 4
1.1.3. The main characteristics of the urban environment: geometric, spectral and temporal. 8
1.1.4. Optical properties of urban materials 10
1.1.5. Spectral characteristics 16
1.2. Main applications of optical remote sensing in urban environments 21
1.2.1. The use of very high spatial resolution multispectral imaging (VHR) for urban mapping and planning 22
1.2.2. Biodiversity (blue belt and green belt) and vegetation detection in cities 34
1.2.3. Urban heat islands 38

1.3. Conclusions and prospects 44
1.4. Key points. 48
1.5. Bibliography 49

Chapter 2. Urban Scene Analysis with Mobile Mapping Technology. 63
Bruno VALLET and Clément MALLET
2.1. Introduction. 63
2.2. Data acquisition 65
2.2.1. Sensors onboard a mobile mapping system. 65
2.2.2. Integrating sensors 71
2.2.3. Geometric calibration 72
2.2.4. Specificities of MMT data. 72
2.3. Data registration and georeferencing 74
2.3.1. Characteristics of the registration procedure 75
2.3.2. Deformation models 76
2.3.3. Pairing methods 77
2.3.4. Pose estimation 78
2.4. Analyzing urban scenes. 80
2.4.1. Local descriptors 80
2.4.2. Segmentation and classification of 3D point clouds. 83
2.4.3. Object recognition 85
2.4.4. Reconstruction. 85
2.4.5. Texturing. 88
2.4.6. 3D change detection 89
2.5. Prospects 91
2.5.1. Uncertainty Management 91
2.5.2. Image/laser fusion 92
2.5.3. Semantization as segmentation/classification coupling. . . . 92
2.5.4. Surface reconstruction and semantization coupling 93
2.5.5. Fusion of aerial and terrestrial data 93
2.6. Key points. 93
2.7. Bibliography 94

Chapter 3. Satellite Imagery: a Tool for Territorial Development 101
Jean Philippe TONNEAU and Pierre MAUREL
3.1. Introduction. 101
3.2. Sustainable territorial development, decision-making and information 102
3.2.1. Regional policies 102

3.2.2. Territorial development process 104
3.2.3. Territorial socio-technical dispositive/ apparatus of information and communication. 106
3.2.4. Functions supporting the territorial decision process 108
3.3. Spatial representations derived from remote sensing 109
3.4. STICA based on spatial representations at the service of integrated land management 112
3.4.1. Thau territory and the challenge of urban sprawl. 112
3.4.2. Use of spatial information for land management in Madagascar 125
3.5. Conclusions 133
3.6. Key points 135
3.7. Bibliography. 135

Chapter 4. Remote Sensing and Ocean Color 141
Malik CHAMI and Tristan HARMEL
4.1. Introduction 141
4.2. Radiation components received by an observation satellite of the ocean color. 143
4.3. Correction of atmospheric effects from satellite images 146
4.3.1. Cloud masking 147
4.3.2. Eliminating sun reflection from the sea (L_G) 148
4.3.3. Estimation of the radiance linked to molecules ($L_{Rayleigh}$) and aerosols ($L_{aerosol}$) 149
4.3.4. Estimation of T_{atm} and T_{gas} transmittances 152
4.3.5. Estimation of the water-leaving radiance L_w 152
4.4. Bio-optical properties of seawater 155
4.4.1. Optical properties of water molecules 155
4.4.2. Optical properties of phytoplankton 156
4.4.3. Optical properties of colored dissolved organic matter 159
4.4.4. Optical properties of the detrital organic matter 160
4.4.5. Optical properties of mineral matters. 161
4.4.6. Additivity of optical properties 161
4.4.7. Definition of the radiometric values used in remote sensing 162
4.5. Determination principle of hydrosol concentrations by satellite 164
4.5.1. Spectral variation of the reflectance according to chlorophyll a 165
4.5.2. Estimation of the concentration in Chl-a. 167

4.6. Examples of ocean color satellite sensors 170
4.7. Some applications of ocean color remote sensing 170
4.7.1. Detection of phytoplanktonic proliferations 170
4.7.2. Estimation of the phytoplankton functional types by satellite 172
4.7.3. Estimation of oceanic primary production 174
4.8. Prospects 176
4.9. Key points. 178
4.10. List of acronyms 179
4.11. Bibliography 180

Chapter 5. LiDAR Measurements and Applications in Coastal and Continental Waters 185
Jean-Stéphane BAILLY, Martin MONTES-HUGO, Yves PASTOL and Nicolas BAGHDADI
5.1. Introduction: history and typology of LiDARs applied to aquatic environments 185
5.2. Equations and parameters of LiDAR systems applied to aquatic environments 188
5.2.1. Water surface return 188
5.2.2. Water column return 190
5.2.3. Water Bottom return 191
5.3. LiDAR acquisitions systems 191
5.3.1. Airborne LiDAR Bathymeter (ALB) systems 191
5.3.2. Oceanographic LiDAR systems 196
5.3.3. Spaceborne LiDAR systems in oceanography 197
5.4. Optical variables derived from LiDAR waveforms 197
5.4.1. Bathymetry. 198
5.4.2. Water and bottom optical properties 199
5.5. Case studies of airborne LiDAR applications in hydrography and oceanography 203
5.5.1. Examples in coastal waters 203
5.5.2. Examples in coastal oceanography. 209
5.5.3. Examples in continental waters. 212
5.6. Prospectives of spaceborne LiDAR mapping of aquatic environments 216
5.7 Key points 218
5.8. Bibliography 218

Chapter 6. Contributions of Airborne Topographic LiDAR to the Study of Coastal Systems 231
Franck LEVOY, Franck GARESTIER, Laurent FROIDEVAL, Olivier MONFORT and Emilie POULLAIN
6.1. Introduction 231
6.2. Characterization of coastal evolution 232
6.2.1. Identification of coastlines for the study of kinematics on open coasts 232
6.2.2. Potential of airborne LiDAR for morphodynamic monitoring and the calculation of sedimentary budgets 240
6.3. Method of identifying the main channels in Mont Saint Michel bay combining topography and LiDAR intensity 246
6.3.1. Hypotheses selected for the extraction of channels 246
6.3.2. Description of data 247
6.3.3. Description of the processing workflow of the channel extraction 248
6.3.4. Results and discussion 252
6.4. Backscattered signal intensity applications 253
6.4.1. Modeling of the backscattered intensity as a function of the incidence angle 253
6.4.2. Characterization of scanned surfaces 256
6.4.3. Anisotropic surface detection by texture analysis 257
6.5. Quantification of the sandy surface moisture of Ls 262
6.6. Prospects 265
6.7. Key points 266
6.8. Bibliography 266

Chapter 7. Mangrove Forest Dynamics Using Very High Spatial Resolution Optical Remote Sensing 269
Christophe PROISY, Jean-Baptiste FÉRET, Nicolas LAURET and Jean-Philippe GASTELLU-ETCHEGORRY
7.1. Introduction 269
7.2. Dynamics of mangrove forests 271
7.2.1. General context 271
7.2.2. The case of Guianese mangrove forests 272
7.2.3. Modeling forest dynamics in mangrove forests 273
7.2.4. Research concerns in VHR optical remote sensing of mangrove forests 274

7.3. Methods 275
7.3.1. Field experiments 275
7.3.2. Modeling 3D radiative transfer with DART 278
7.4. Application to the monitoring of Guianese mangrove forest dynamics 284
7.4.1. Principles, potential and limits of the FOTO method 284
7.4.2. Potential and limits of simulated images 288
7.5. Conclusion and prospects. 290
7.6. Key points. 291
7.7. Bibliography 291

Chapter 8. Remote Sensing-based Monitoring of the Muddy Mangrove Coastline of French Guiana 297
Romain WALCKER, Nicolas GRATIOT and Edward J. ANTHONY
8.1. Introduction. 297
8.1.1. The state of mangrove coastlines: information derived from remote sensing 297
8.1.2. The Guianas' mangrove coastline: a challenge for coastal applications of remote sensing 298
8.1.3. Chapter outline 299
8.2. Monitoring coastal water color with remote sensing. 299
8.2.1. The concentration of phytoplankton and the biogeochemical composition of coastal waters. 299
8.2.2. Water color as an indicator of sediment dynamics 300
8.2.3. Estimating the concentration of SPM using remote sensing 301
8.2.4. Satellites used to study water color 303
8.3. Remote sensing of coastal mud banks 303
8.3.1. Problem of delineation of mud banks linked to tides 303
8.3.2. Monitoring the migration of mud banks. 304
8.3.3. Radar remote sensing of mud banks 306
8.4. Monitoring the shoreline with remote sensing 307
8.4.1. The shoreline: definition and issues posed by a multi-faceted feature 307
8.4.2. Exceptional dynamics of the Guianas' coastline. 308
8.5. Intertidal topography 311
8.5.1. Ground surveys using a laser tacheometer or differential GPS 311
8.5.2. Interpolation of water level isolines on satellite images 312

8.5.3. Airborne LiDAR 314
8.5.4. Photogrammetry 315
8.6. Conclusion 315
8.7. Key points 316
8.8. Bibliography 317

Glossary 321

List of Authors 341

Index 345

Scientific Committee 349