
Contents

Foreword	xiii
Acronyms	xvii
Introduction	xli
Chapter 1. Mapping of Primary Soil Properties Using Optical Visible and Near Infrared (Vis-NIR) Remote Sensing	1
Cécile GOMEZ and Phillipe LAGACHERIE	
1.1. Introduction.	1
1.2. Spectral signatures of soils.	3
1.3. Estimation of soil properties from their spectral signatures	5
1.3.1. The spectral indices approach	6
1.3.2. The chemometric approach	8
1.3.3. Calibration/Validation	11
1.3.4. Performance indicators of these models	12
1.4. Direct uses of estimation models	14
1.4.1. Example of primary soil properties mapping using multispectral Vis-NIR imaging	16
1.4.2. Example of primary soil properties mapping using hyperspectral Vis-NIR imagery.	18
1.4.3. Limits.	21

1.5. Use of the Vis-NIR remote sensing products for digital soil mapping.	22
1.5.1. Using Vis-NIR remote sensing products as a new data source for DSM.	24
1.5.2. Using Vis-NIR remote sensing products as DSM variables	25
1.6. Perspectives	26
1.7. Key points	27
1.8. Bibliography	28

Chapter 2. Estimation of Biophysical Variables from Satellite Observations

Fred BARET

2.1. Introduction.	37
2.2. Definition of the canopy biophysical variables accessible from remote sensing observations.	39
2.2.1. Leaf Area index: LAI, GLAI, PAI, GAI, apparent and effective values.	39
2.2.2. FAPAR: illumination geometry and distinction between green and non-green elements.	41
2.3. Inversion methods of radiative transfer models.	42
2.3.1. Approaches focusing on radiometric variables.	43
2.3.2. Approaches focusing on the variables of interest: machine learning	45
2.3.3. Advantages and limitations of several approaches	48
2.4. Theoretical performances in estimating the different variables of interest	50
2.5. How to manage the under-determined and ill-posed nature of the inverse problem?	51
2.5.1. The under-determination and ill-posed nature of the inverse problem.	51
2.5.2. Reducing RTM uncertainties	54
2.5.3. Using prior information	56
2.5.4. Use of additional constraints	58
2.6. Combination of methods and sensors to improve estimates	60
2.6.1. Hybrid methods and ensemble products	60
2.6.2. Sensor combination to build long-time series	62
2.7. Conclusion	65
2.8. Key points	67
2.9. Bibliography	68

Chapter 3. Land Cover Mapping from Optical Images	81
Jordi INGLADA	
3.1. Introduction.	81
3.1.1. Remote sensing imagery mapping	81
3.1.2. Land cover and land use.	82
3.1.3. Nomenclatures	83
3.1.4. Detection of land cover change.	86
3.2. The input data	86
3.2.1. Types of imagery	87
3.2.2. Reference data for calibration and validation	91
3.3. Land cover map production approaches	92
3.3.1. Map validation	92
3.3.2. Feature extraction.	95
3.3.3. Classification methods.	102
3.3.4. Change detection	105
3.4. Use examples.	105
3.4.1. Generic land cover mapping	106
3.4.2. Detailed mapping of agricultural crops	108
3.5. Key points	110
3.6. Bibliography	110
Chapter 4. Contribution of Remote Sensing for Crop and Water Monitoring	113
Dominique COURAULT, Valérie DEMAREZ, Martine GUÉRIF, Michel LE PAGE, Vincent SIMONNEAUX, Sylvain FERRANT and Amanda VELOSO	
4.1. Introduction.	113
4.2. Indicators for crop monitoring.	117
4.3. Indicators of agricultural practices at the territory level.	119
4.3.1. Crop type identification and succession.	119
4.3.2. Characterization of agricultural practices.	121
4.4. Estimating water status and the water needs of crops using models	133
4.4.1. Evapotranspiration estimation using a simplified model of the water balance	134
4.4.2. Irrigation management in operational mode in near real time at plot level	138
4.5. Agricultural production quantification	140
4.5.1. Reminder on crop models	141

4.5.2. Review on the use of remote sensing data combined with crop models.	142
4.5.3. Biomass and yield estimate by forcing simple models.	143
4.5.4. Biomass and yield estimate by forcing semi-empirical models.	146
4.5.5. Biomass and yield estimates from complex models.	147
4.6. Some cases studies of environmental impacts of agriculture: spatial modeling of water, nitrogen and CO ₂ fluxes	151
4.6.1. Analysis of the impact of irrigation on the recharge of groundwater (integrated modeling approach)	152
4.6.2. The spatial modeling of water and nitrogen flows.	154
4.6.3. The spatial modeling of CO ₂ fluxes and carbon budget	158
4.7. Precision agriculture	160
4.7.1. Indicator-based advice for crop management	161
4.7.2. Advice based on the use of crop models	165
4.8. Results and prospects	167
4.9. Key points	168
4.10. Bibliography	168
Chapter 5. Contribution of Remote Sensing to Crop Monitoring in Tropical Zones	179
Pierre TODOROFF and Jaco KEMP	
5.1. Introduction: the case of tropical crops	179
5.1.1. Remote sensing issues for monitoring tropical crops	179
5.1.2. Specific contexts	180
5.2. Crop mapping	183
5.2.1. Example of a method for analyzing optical image time series to map sugarcane plots in Kenya	184
5.2.2. Example of object-based image analysis of VHRS optical images to map land use and crops on Reunion Island.	188
5.2.3. Potential of radar polarimetry in South Africa.	196
5.3. Yield prediction	203
5.3.1. Example of yield prediction using optical remote sensing	204
5.4. Harvest monitoring	209
5.4.1. Issues	209
5.4.2. Example of sugarcane harvest monitoring by remote sensing on Reunion Island.	210

5.5. Conclusion and outlook.	213
5.6. Key points	215
5.7. Bibliography	215
Chapter 6. Monitoring of Agricultural Landscapes Using Remote Sensing Data	221
Samuel CORGNE, Laurence HUBERT-MOY and Julie BETBEDER	
6.1. Introduction.	221
6.2. Identifying winter land cover within the framework of intensive agriculture.	225
6.2.1. Overall context	225
6.2.2. Study site and data	226
6.2.3. Methodology	228
6.2.4. Results	231
6.3. Phenology monitoring and crop characterization from a series of radar images	235
6.3.1. Overall context	235
6.3.2. Study site and data	235
6.3.3. Methodology	237
6.3.4. Results	238
6.4. Prospects	242
6.5. Key points	244
6.6. Bibliography	244
Chapter 7. Applications of Multispectral Optical Satellite Imaging in Forestry	249
Dominique GUYON and Nathalie BRÉDA	
7.1. Introduction.	249
7.2. Specific key points of the forest cover	252
7.2.1. Structure of forest cover and reflectance	252
7.2.2. What information about forest cover can be expected?	261
7.3. Examples of application	281
7.3.1. Estimation and management of forest resource: wood volume, above ground biomass, carbon stocks.	281
7.3.2. Monitoring of the functional response of forests exposed to climate and hazards	302
7.4. Prospects	317
7.5. Key points	319
7.6. Bibliography	319

Chapter 8. Characterization of Forests with LiDAR Technology	331
Adrien MICHEZ, Sébastien BAUWENS, Stéphanie BONNET and Philippe LEJEUNE	
8.1. Introduction.	331
8.2. The LiDAR technology.	332
8.3. LiDAR technology in forestry: platforms and applications.	333
8.3.1. Satellite LiDAR : example of an ICESat project	334
8.3.2. Airborne LiDAR	337
8.3.3. Terrestrial LiDAR	345
8.4. Future of LiDAR technology in forestry?	352
8.4.1. Technological evolution.	352
8.4.2. Multispectral LiDAR and combination of ALS LiDAR data with optical data	353
8.4.3. Towards a global mapping of world forests using LiDAR data?	353
8.5. Key points	354
8.6. Bibliography	355
 Chapter 9. Forest Biomass from Radar Remote Sensing	 363
Ludovic VILLARD, Thuy LE TOAN, Dinh HO TONG MINH, Stéphane MERMOZ and Alexandre BOUVET	
9.1. Forest biomass at the global scale.	363
9.1.1. Forest biomass, an essential climate variable	363
9.1.2. Expectations for a better understanding of biomass globally: users and needs	367
9.1.3. Towards forest biomass mapping globally: issues and solutions	370
9.2. Quantifying forest biomass with radar remote sensing: physics and measurement techniques	375
9.2.1. Interaction mechanisms between microwaves and vegetation scatterers, relationship with biomass	375
9.2.2. Relevant SAR measurements and techniques for biomass	386
9.3. Biomass from SAR L band	400
9.3.1. Introduction	400
9.3.2. The relationship between radar measurements (L band) and biomass	402
9.3.3. Inversion in the relationship between radar measurements (L band) and biomass	407

9.4. The BIOMASS mission: forest biomass with P-band SAR.	407
9.4.1. Scientific objectives of the mission	408
9.4.2. Concept of the biomass mission	409
9.5. Summary and prospects	414
9.6. Key points	415
9.7. Bibliography	416
Glossary	427
List of Authors	445
Index	449
Scientific Committee	453