

Contents

Preface	V
About the Editors	VII
Authors	IX
Section I: Overview and Basic Principles	1
Chapter 1 Introduction	3
1.1 Introduction	3
1.2 Remote Sensing Defined	3
1.3 The Nature of Remote Sensing Data	4
1.4 Satellite Systems	6
1.4.1 Remote Sensing Platforms.....	6
1.4.2 Remote Sensing Sensors	9
1.4.3 Spatial Resolution.....	10
1.4.4 Temporal Resolution	12
1.5 Remote Sensing and Hydrology	12
1.6 Structure of the Book	13
Chapter 1 Physical Principles and Technical Aspects of Remote Sensing	15
1.7 Introduction	15
1.8 The Electromagnetic Spectrum and Radiation Laws	15
1.9 Atmospheric Propagation.....	21
1.10 Reflection and Emission Characteristics of Natural Media	26
1.11 Sensor Principles.....	30
1.12 Summary of Current and Future Earth Observation Missions	37
Chapter 2 Processing Remotely Sensed Data: Hardware and Software Considerations	41
2.1 Image Processing System Characteristics	41
2.1.1 The Central Processing Unit (CPU): Personal Computers, Workstations and Mainframes	41
2.1.2 Number of Analysts on a System and Mode of Operation	44
2.1.3 Serial versus Parallel Image Processing, Arithmetic Coprocessor, and Random Access Memory (RAM).....	44
2.1.4 Operating System and Software Compilers.....	46
2.1.5 Mass Storage	47

2.1.6	Screen Display Resolution	48
2.1.7	Screen Color Resolution	49
2.1.8	Image Scanning (Digitization) Considerations	49
2.2	Image Processing and GIS Software Requirement	50
2.2.1	Preprocessing	52
2.2.2	Display and Enhancement.	52
2.2.3	Remote Sensing Information Extraction.	53
2.2.4	Photogrammetric Information Extraction.	54
2.2.5	Metadata and Image/Map Lineage Documentation	54
2.2.6	Image and Map Cartographic Composition	57
3.2.7	Geographic Information Systems (GIS)	57
3.2.8	Utilities	57
2.3	Commercial and Publicly Available Digital Image Processing Systems	58
2.4	Summary	58
Chapter 3	Integration of Remotely Sensed Data into Geographical Information Systems	65
3.1	Introduction.	65
3.2	General Approach	67
3.2.1	Raster and Vector Data Structures	67
3.2.2	Current Approaches to the Integration	70
3.2.3	Errors Associated with Geographical Processing	71
3.3	Current Applications	72
3.3.1	Watershed Database Development	72
3.3.2	Integrated Use of Elevation Data.	73
3.3.3	Land-use/Land-cover Change Detection	74
3.3.4	Modeling Watershed Runoff	75
3.3.5	Monitoring and Modeling of Water Quality	76
3.3.6	Soil Erosion Monitoring	77
3.4	Future Perspectives	78
Section II:	Remote Sensing Application to Hydrologic Monitoring and Modeling	83
Chapter 4	Remote Sensing in Hydrological Modeling	85
4.1	Introduction.	85
4.2	Remote Sensing in Operational Hydrologic Modeling	87
4.3	Remote Sensing in Coupled Water-Energy Balance Modeling	90
4.4	Remote Sensing Approach	92
4.4.1	Solar radiation	92
4.4.2	Downwelling longwave.	93
4.4.3	Precipitation	94

4.4.4	Air Temperature	94
4.4.5	Surface Air Humidity	95
4.5	Modeling Example: The Red River Arkansas Basin	96
4.6	Future Directions	97
Colour Plates of Chaps. 2-5		103
Chapter 5	Precipitation	111
5.1	Introduction	111
5.2	General Approach	112
5.2.1	Ground-based radar	112
5.2.2	Use of visible and infrared satellite data	114
5.2.3	Use of passive microwave satellite data	114
5.2.4	Space-borne radar	115
5.3	Current Techniques	115
5.3.1	Single polarisation radar measurements of rainfall	115
5.3.2	Measurement of snowfall and hail	118
5.3.3	Multi-parameter radar	120
5.3.4	Satellite cloud indexing and life history methods of rainfall estimation	121
5.3.5	Bispectral techniques	123
5.3.6	Passive microwave estimates of rainfall from space	124
5.3.7	Sampling errors	126
5.4	The potential for improvement	127
5.4.1	Current performance levels	127
5.4.2	The future	128
Chapter 6	Land-use and Catchment Characteristics	133
6.1	Introduction	133
6.2	Land cover Mapping with Remote Sensing	134
6.3	Vegetation Indices	135
6.3.1	Simple Vegetation Indices	136
6.3.2	Normalized Difference Vegetation Index (NDVI)	138
6.3.3	Refined estimates	139
6.3.4	Multi-temporal Vegetation Index	140
6.4	Thematic Classification	140
6.4.1	Image Classification Methods	142
6.4.2	Maximum Likelihood Classification	145
6.4.3	Discussion	147
6.4.4	Probability estimation refinements	147
6.4.5	Segmentation	149
6.4.6	Case study in the Pantanal Area, Brazil	150
6.5	Radar	152
Chapter 7	Evaporation	157
8.1.	Introduction	157

7.1.1	General	157
7.1.2	Remote sensing of land evaporation	158
7.2	Evaporation and radiometric variables	160
7.2.1	Potential Evaporation	160
7.2.2	Actual Evaporation	162
7.3	Remote Sensing of Land Evaporation: Applications and Modelling Approaches	165
7.3.1	General	165
7.3.2	Linear relationships between evaporation and land surface temperature [1]	166
7.3.3	Improved linear relationships [2]	167
7.3.4	Relationships between evaporation, surface, temperature and spectral indices [3]	168
7.3.5	Soil Vegetation Atmosphere Transfer (SVAT) models [4]	169
7.3.6	Integrated SVAT and Planetary Boundary Layer (PBL) models [5]	170
7.4	Current trends: improved observations and improved parameterizations	171
7.4.1	Local maximum evaporation and land surface temperature [6]	171
7.4.2	Improved observation of land surface variables [7]	174
7.5	Spatial variability	177
7.6	Accuracy	178
7.7	Applications	179
7.8	Current and Future Observations	180
7.9	Summary and Conclusions	181
Colour Plates of Chaps. 6-8		189
Chapter 9	Soil Moisture	197
9.2	Introduction	197
9.3	General Approach	198
9.4	Sensor-Target Interactions	202
9.5	Hydrologic Examples	209
9.6	Future Microwave Remote Sensing of Soil Moisture	212
Chapter 10	Remote Sensing of Surface Water	217
10.2	Introduction	217
10.2	Surface Water Detection	218
10.3	Lake and Reservoir Area Estimates	220
10.4	Wetlands	223
10.5	Lake Levels	224
10.6	River Levels and Flows	226

10.7	Flood Extent.....	230
10.8	Conclusion	233
Chapter 11	Snow and Ice	239
11.2	Role of Snow and Ice	239
11.3	General Approach.....	240
11.2.1	Gamma Radiation.....	240
11.2.1	Visible Imagery.....	242
11.3.1	Thermal Infrared.....	244
11.3.2	Passive and Active Microwave.....	244
11.3.3	Related Applications.....	248
11.4	Current Applications	249
11.3.1	NOHRSC– Snow Cover and Snow Water Equivalent Products.....	249
9.2.1	Canadian Prairie Snow Water Equivalent Mapping.....	250
9.2.1	Snowmelt Runoff Forecast Operations.....	252
11.5	Future Directions.....	255
11.5.1	Improved Resolution in the Passive Microwave	255
11.5.2	Improved Algorithms in the Passive Microwave	256
11.5.3	Outlook for Radar Applications	256
11.5.4	Integration of Various Data Types	257
	Colour Plates of Chaps. 9-11	263
Chapter 12	Soil Erosion.....	271
12.2	Introduction	271
12.2	Basis for using Remote Sensing	273
12.3	Applications.....	274
12.4	Case Studies.....	276
12.4.1	Photointerpretation/Photogrammetry.....	277
12.4.2	Model/GIS Inputs	279
12.4.3	Spectral Properties	280
12.4.4	Topographic Measurements	281
12.5	Future Directions.....	282
Chapter 13	Water Quality	287
13.2	Introduction	287
13.2	Basis for using Remote Sensing	288
13.3	Application.....	290
13.4	Case Studies.....	291
13.4.1	Suspended Sediments	291
13.4.2	Chlorophyll	294
13.4.3	Temperature.....	297
13.4.4	Oils	298
13.5	Future Directions.....	299

Chapter 14	Groundwater	305
14.2	Introduction	305
14.2	Conceptualization of the hydrogeology	306
14.2.1	The three dimensional hydrogeologic situation	306
14.2.2	Groundwater surface	309
14.2.3	Flow systems	310
14.3	Aspects of water budgets	312
14.3.1	Groundwater irrigation drafts	312
14.3.2	Recharge	313
14.4	Hard rock terrain and lineaments	319
14.5	Groundwater management and conclusions	321
14.6	Conclusions and future perspectives	322
Section III:	Water Management with the Aid of Remote Sensing Data	327
Chapter 15	Introduction to and General Aspects of Water Management with the aid of Remote Sensing	329
15.2	Introduction	329
15.2	Potential of remote sensing in water management	329
15.2.1	Surveying and mapping	330
15.2.2	Spatial analysis and regionalization	332
15.2.3	Monitoring and forecasting	332
15.3	River basin planning with the aid of remote sensing	334
15.3.1	Introduction	334
15.3.2	Hydrologic monitoring & forecasting	334
15.3.3	Upstream-downstream interrelationships in river basins	335
15.4	Watershed management with the aid of remote sensing	338
15.4.1	Introduction	338
15.4.2	Hydrologic photo-interpretation for watershed management	338
15.5	Small-scale water resource development and remote sensing	340
15.5.1	Introduction	340
15.5.2	Runoff water harvesting with the aid of remote sensing	340
15.5.3	Flood spreading and groundwater recharge	341
15.6	Irrigation water management and remote sensing	341
15.7	Decision support systems for water management	342
15.7.1	Introduction	342
15.7.2	Expert and decision support systems	342
Colour Plates of Chaps. 12-15		349

Chapter 16	Flood Forecasting and Control	357
16.2	Introduction	357
16.2	General Approach	358
16.2.1	Modeling Philosophy	358
16.2.2	Remote Sensing Data, Types and Acquisition	360
16.2.3	Determination of Hydro-meteorological Information from Remote Sensing Data	360
16.2.4	Transformation of Area Precipitation into a Real-time Forecast of a Runoff Hydrograph	362
16.3	Real-time Flood Control with the Aid of Flood Forecasts Based on Remote Sensing Data – an Example	365
16.3.1	Basic Principle	365
16.3.2	Radar Rainfall Measurements in the Günz River Catchment	367
16.3.3	Quantitative Precipitation Forecast (QPF)	368
16.3.4	Rainfall-Runoff-Model Application for Flood Forecasting	368
16.3.5	Optimum Reservoir Operation Based on Forecast Flood Hydrographs	370
16.4	Flood Forecasting and Control in an Urban Environment	372
16.5	Future Perspectives	375
Chapter 17	Irrigation and Drainage	377
17.2	Introduction	377
17.1.1	Current non-remote sensing approaches and limitations	378
17.1.2	Reviews of remote sensing applications in irrigation and drainage	379
17.2	General Approach	380
17.2.1	Applications versus Observables and Algorithms	380
17.2.2	Theory and conceptual approach	380
17.2.3	Examples of applications	386
17.3	Current Applications	387
17.3.1	General	387
17.3.2	High resolution mapping of irrigated lands	389
17.3.3	Crop water requirements – Visible and Near Infrared	390
17.3.4	Crop water stress – Thermal Infrared	391
17.3.5	Catchment hydrology	392
17.3.6	Detection of saline areas	392
17.3.7	Irrigation management	393
17.4	Current and future observations	394
17.5	Future Directions and Potential	395
Chapter 18	Computation of Hydrological Data for Design of Water Projects in Ungauged River Basins	401
18.2	Introduction	401

18.2	General Approach	403
18.2.1	MODUL I: Satellite system, data processing	403
18.2.2	MODUL II: Assessment of the monthly area precipitation on the basis of multi-temporal satellite imagery	406
18.2.3	MODUL III: Estimation of runoff values	409
18.3	Application	410
18.3.1	Study area and data used	410
18.3.2	Assessment of the monthly area precipitation with the aid of multi-temporal B2-Meteosat satellite imagery	411
18.3.3	Rainfall – Runoff Model	413
18.4	Further Applications	414
18.5	Summary and Discussion	416
Chapter 19	Detection of Land Cover Change Tendencies and their Effect on Water Management	419
19.2	General Remarks	419
19.2	Hydrological Modelling and Land Cover Change	422
19.3	A Case Study: Land Use Change Detection by Remote Sensing in the Sauer River Basin, Western Europe	424
19.4	Summary	432
Colour Plates of Chaps. 16-19		435
Section IV: Future Perspectives		443
Chapter 20	Future Perspectives	445
20.2	Introduction	445
20.2	Status of Hydrologic Research and Modeling	446
20.3	Water Management	448
20.4	Data Issues in Hydrology and Water Resources Management	449
20.5	Intensive Field Campaigns	452
20.6	Existing Sensors and Platforms	453
20.7	Planned and Proposed Sensors and Platforms	454
20.8	Remote Sensing and Future Needs in Hydrology	456
Appendix 20.1	Existing and Future Remote Sensing Satellites and Sensors Relevant to Hydrological Applications	458
Appendix 20.2	Specification for Sensors Listed in Appendix 20.1	461
List of Acronyms		471
Index		475

Remote Sensing in Hydrology and Water Management

Schultz, G.A.; Engman, E.T. (Eds.)

2000, XX, 483 p. 52 illus. in color., Hardcover

ISBN: 978-3-540-64075-2