
Contents

Acknowledgments	ix
The Author	xi
Abbreviations	xiii
Statement on Trade Names and Trademarks	xv

1. Introduction	1
Metaphors of Nature	2
A Solution Space?	4
Scope and Plan of This Book	5

Section I

2. From GIS to Geocomputation	11
In the Beginning	12
Technological Facilitation	14
Representing Spatial Phenomena in GIS	19
Putting the Real World onto Media	24
Vector	26
Tessellations	28
Object-Oriented	31
Data Characteristics	32
Data Collection Technologies	37
GPS and Inertial Navigation Systems	38
Remote Sensing	39
Ground Survey	41
Nontraditional Approaches to Data Collection	42
Basic Functionality of GIS	42
A Systems Definition of GIS	44
Limitations of GIS and the Rise of Geocomputation and Geosimulation	46
3. GIScience and the Rise of Geo-Information Engineering	49
Technology First	49
Science to Follow	52
And Now ... Geo-Information Engineering	59

Section II

4. Approaches to Modeling	63
Model of an x	64
Typology of Models.....	66
Building Models.....	69
Modeling Landslides.....	70
Modeling Topography.....	75
Spatio-Temporal Dimensions and the Occam–Einstein Dimension.....	77
Evaluating Models.....	81
Applying Models.....	83
A Summary of Model Development.....	87
5. The Role and Nature of Environmental Models	91
Context of Environmental Modeling.....	92
Environmental Impact Assessment.....	94
An Integrated Approach.....	97
Sustainable Development.....	99
Hazard, Vulnerability, and Risk.....	101
Decision Environment.....	105
Conceptual Models.....	107
Empirical Models.....	110
Models Incorporating Artificial Intelligence.....	117
Knowledge-Based Systems.....	117
Heuristics.....	118
Artificial Neural Networks.....	119
Agent-Based Models.....	121
Process Models.....	124
Lumped Parameter Models.....	126
Distributed Parameter Models.....	131
Discretization.....	131
Routing across a Digital Elevation Model.....	132
Transport through a Medium.....	134

Section III

6. Case Studies in GIS, Environmental Modeling, and Engineering	147
Modeling Approaches in GIS and Environmental Modeling.....	147
Spatial Coexistence.....	150
Source–Pathway Characterization.....	157
Basin Management Planning.....	158

Coastal Oil Spill Modeling	169
Cluster Detection	172
... and Don't Forget the Web	182
7. Issues of Coupling the Technologies.....	185
Some Preconditions	186
Initial Conceptualizations	189
Independent.....	190
Loosely Coupled.....	190
Tightly Coupled.....	191
Embedded	191
An Over-Simplification of the Issues	192
Maturing Conceptualizations.....	197
Integration versus Interoperability	198
Environmental Modeling within GIS	201
Model Management.....	203
Maturing Typology of Integration	207
One-Way Data Transfer	207
Loose Coupling	207
Shared Coupling	209
Joined Coupling.....	209
Tool Coupling	209
<i>De facto</i> Practices	210
8. Data and Information Quality Issues	213
The Issue Is ... Uncertainty	213
Early Warnings.....	217
So, How Come ... ?	219
Imperfect Measurement.....	219
Digital Representation of Phenomena	220
Natural Variation	221
Subjective Judgment and Context.....	223
Semantic Confusion.....	224
Finding a Way Forward	224
Measuring Spatial Data Quality	226
Modeling Error and Uncertainty in GIS.....	231
Topological Overlay	231
Interpolation	236
Kriging.....	238
Fuzzy Concepts in GIS.....	242
Theory of Fuzzy Sets	243
Example of Fuzzy Sets in GIS.....	244
Sensitivity Analysis	256
Managing Fitness-for-Use	259

9. Modeling Issues 263

 Issues of Scale 264

 Issues of Algorithm 277

 Issues of Model Structure 285

 Issues of Calibration 288

 Bringing Data Issues and Modeling Issues Together 293

10. Decision Making under Uncertainty 297

 Exploring the Decision Space: Spatial Decision Support Systems..... 299

 Communication of Spatial Concepts..... 304

 Participatory Planning and the Web-Based GIS 307

 All's Well That Ends Well?..... 311

References 315

Index 341