

Contents

Preface	v
Introduction	1
<i>Manfred M. Fischer and Arthur Getis</i>	
PART A GI Software Tools	
A.1 Spatial Statistics in ArcGIS	
<i>Lauren M. Scott and Mark V. Janikas</i>	
A.1.1 Introduction	27
A.1.2 Measuring geographic distributions	28
A.1.3 Analyzing patterns	30
A.1.4 Mapping clusters	33
A.1.5 Modeling spatial relationships	35
A.1.6 Custom tool development	38
A.1.7 Concluding remarks	39
References	40
A.2 Spatial Statistics in SAS	
<i>Melissa J. Rura and Daniel A. Griffith</i>	
A.2.1 Introduction	43
A.2.2 Spatial statistics and SAS	43
A.2.3 SAS spatial analysis built-ins	44
A.2.4 SAS implementation examples	45
A.2.5 Concluding remarks	51
References	51
A.3 Spatial Econometric Functions in R	
<i>Roger S. Bivand</i>	
A.3.1 Introduction	53
A.3.2 Spatial models and spatial statistics	55
A.3.3 Classes and methods in modelling using R	57
A.3.4 Issues in prediction in spatial econometrics	60
A.3.5 Boston housing values case	65
A.3.6 Concluding remarks	68
References	69

A.4	GeoDa: An Introduction to Spatial Data Analysis	
	<i>Luc Anselin, Ibnu Syabri and Youngihn Kho</i>	
A.4.1	Introduction	73
A.4.2	Design and functionality	76
A.4.3	Mapping and geovisualization	78
A.4.4	Multivariate EDA	80
A.4.5	Spatial autocorrelation analysis	82
A.4.6	Spatial regression	84
A.4.7	Future directions	86
	References	87
A.5	STARS: Space-Time Analysis of Regional Systems	
	<i>Sergio J. Rey and Mark V. Janikas</i>	
A.5.1	Introduction	91
A.5.2	Motivation	92
A.5.3	Components and design	92
A.5.4	Illustrations	98
A.5.5	Concluding remarks	109
	References	111
A.6	Space-Time Intelligence System Software for the Analysis of Complex Systems	
	<i>Geoffrey M. Jacquez</i>	
A.6.1	Introduction	113
A.6.2	An approach to the analysis of complex systems	115
A.6.3	Visualization	116
A.6.4	Exploratory space-time analysis	117
A.6.5	Analysis and modeling	119
A.6.6	Concluding remarks	122
	References	123
A.7	Geostatistical Software	
	<i>Pierre Goovaerts</i>	
A.7.1	Introduction	125
A.7.2	Open source code versus black-box software	127
A.7.3	Main functionalities	128
A.7.4	Affordability and user-friendliness	131
A.7.5	Concluding remarks	132
	References	133
A.8	GeoSurveillance: GIS-based Exploratory Spatial Analysis Tools for Monitoring Spatial Patterns and Clusters	
	<i>Gyoungju Lee, Ikuho Yamada and Peter Rogerson</i>	
A.8.1	Introduction	135
A.8.2	Structure of GeoSurveillance	137

A.8.3	Methodological overview	138
A.8.4	Illustration of GeoSurveillance	142
A.8.5	Concluding remarks	148
	References	149
A.9	Web-based Analytical Tools for the Exploration of Spatial Data <i>Luc Anselin, Yong Wook Kim and Ibnu Syabri</i>	
A.9.1	Introduction	151
A.9.2	Methods	152
A.9.3	Architecture	158
A.9.4	Illustrations	163
A.9.5	Concluding remarks	170
	References	171
A.10	PySAL: A Python Library of Spatial Analytical Methods <i>Sergio J. Rey and Luc Anselin</i>	
A.10.1	Introduction	175
A.10.2	Design and components	177
A.10.3	Empirical illustrations	180
A.10.4	Concluding remarks	191
	References	191
 PART B Spatial Statistics and Geostatistics		
B.1	The Nature of Georeferenced Data <i>Robert P. Haining</i>	
B.1.1	Introduction	197
B.1.2	From geographical reality to the spatial data matrix	199
B.1.3	Properties of spatial data in the spatial data matrix	204
B.1.4	Implications of spatial data properties for data analysis	208
B.1.5	Concluding remarks	214
	References	214
B.2	Exploratory Spatial Data Analysis <i>Roger S. Bivand</i>	
B.2.1	Introduction	219
B.2.2	Plotting and exploratory data analysis	220
B.2.3	Geovisualization	224
B.2.4	Exploring point patterns and geostatistics	229
B.2.5	Exploring areal data	236
B.2.6	Concluding remarks	249
	References	250

B.3	Spatial Autocorrelation	
	<i>Arthur Getis</i>	
B.3.1	Introduction	255
B.3.2	Attributes and uses of the concept of spatial autocorrelation	257
B.3.3	Representation of spatial autocorrelation	259
B.3.4	Spatial autocorrelation measures and tests	262
B.3.5	Problems in dealing with spatial autocorrelation	272
B.3.6	Spatial autocorrelation software	274
	References	275
B.4	Spatial Clustering	
	<i>Jared Aldstadt</i>	
B.4.1	Introduction	279
B.4.2	Global measures of spatial clustering	280
B.4.3	Local measures of spatial clustering	289
B.4.4	Concluding remarks	297
	References	298
B.5	Spatial Filtering	
	<i>Daniel A. Griffith</i>	
B.5.1	Introduction	301
B.5.2	Types of spatial filtering	303
B.5.3	Eigenfunction spatial filtering and generalized linear models	312
B.5.4	Eigenfunction spatial filtering and geographically weighted regression	313
B.5.5	Eigenfunction spatial filtering and geographical interpolation	315
B.5.6	Eigenfunction spatial filtering and spatial interaction data	316
B.5.7	Concluding remarks	317
	References	317
B.6	The Variogram and Kriging	
	<i>Margaret A. Oliver</i>	
B.6.1	Introduction	319
B.6.2	The theory of geostatistics	319
B.6.3	Estimating the variogram	321
B.6.4	Modeling the variogram	327
B.6.5	Case study: The variogram	331
B.6.6	Geostatistical prediction: Kriging	337
B.6.7	Case study: Kriging	344
	References	350

Part C Spatial Econometrics

C.1	Spatial Econometric Models	
	<i>James P. LeSage and R. Kelley Pace</i>	
C.1.1	Introduction	355
C.1.2	Estimation of spatial lag models	360
C.1.3	Estimates of parameter dispersion and inference	365
C.1.4	Interpreting parameter estimates	366
C.1.5	Concluding remarks	374
	References	374
C.2	Spatial Panel Data Models	
	<i>J. Paul Elhorst</i>	
C.2.1	Introduction	377
C.2.2	Standard models for spatial panels	378
C.2.3	Estimation of panel data models	382
C.2.4	Estimation of spatial panel data models	389
C.2.5	Model comparison and prediction	399
C.2.6	Concluding remarks	403
	References	405
C.3	Spatial Econometric Methods for Modeling Origin-Destination Flows	
	<i>James P. LeSage and Manfred M. Fischer</i>	
C.3.1	Introduction	409
C.3.2	The analytical framework	410
C.3.3	Problems that plague empirical use of conventional spatial interaction models	416
C.3.4	Concluding remarks	431
	References	432
C.4	Spatial Econometric Model Averaging	
	<i>Olivier Parent and James P. LeSage</i>	
C.4.1	Introduction	435
C.4.2	The theory of model averaging	436
C.4.3	The theory applied to spatial regression models	440
C.4.4	Model averaging for spatial regression models	444
C.4.5	Applied illustrations	450
C.4.6	Concluding remarks	458
	References	459
C.5	Geographically Weighted Regression	
	<i>David C. Wheeler and Antonio Páez</i>	
C.5.1	Introduction	461
C.5.2	Estimation	462
C.5.3	Issues	467

C.5.4	Diagnostic tools	469
C.5.5	Extensions	472
C.5.6	Bayesian hierarchical models as an alternative to GWR	474
C.5.7	Bladder cancer mortality example	477
	References	484
C.6	Expansion Method, Dependency, and Multimodeling <i>Emilio Casetti</i>	
C.6.1	Introduction	487
C.6.2	Expansion method	488
C.6.3	Dependency	493
C.6.4	Multimodeling	496
C.6.5	Concluding remarks	501
	References	502
C.7	Multilevel Modeling <i>S.V. Subramanian</i>	
C.7.1	Introduction	507
C.7.2	Multilevel framework: A necessity for understanding ecological effects	509
C.7.3	A typology of multilevel data structures	510
C.7.4	The distinction between levels and variables	511
C.7.5	Multilevel analysis	512
C.7.6	Multilevel statistical models	513
C.7.7	Exploiting the flexibility of multilevel models to incorporating 'realistic' complexity	521
C.7.8	Concluding remarks	523
	References	524

Part D The Analysis of Remotely Sensed Data

D.1	ARTMAP Neural Network Multisensor Fusion Model for Multiscale Land Cover Characterization <i>Sucharita Gopal, Curtis E. Woodcock and Weiguo Liu</i>	
D.1.1	Background: Multiscale characterization of land cover	529
D.1.2	Approaches for multiscale land cover characterization	530
D.1.3	Research methodology and data	532
D.1.4	Results and analysis	534
D.1.5	Concluding remarks	540
	References	541
D.2	Model Selection in Markov Random Fields for High Spatial Resolution Hyperspectral Data <i>Francesco Lagona</i>	
D.2.1	Introduction	545

D.2.2	Restoration, segmentation and classification of HSRH images	549
D.2.3	Adjacency selection in Markov random fields	550
D.2.4	A study of adjacency selection from hyperspectral data	554
D.2.5	Concluding remarks	560
	References	561
D.3	Geographic Object-based Image Change Analysis <i>Douglas Stow</i>	
D.3.1	Introduction	565
D.3.2	Purpose of GEOBICA	566
D.3.3	Imagery and pre-processing requirements	568
D.3.4	GEOBIA principles	569
D.3.5	GEOBICA approaches	571
D.3.6	GEOBICA strategies	572
D.3.7	Post-processing	575
D.3.8	Accuracy assessment	576
D.3.9	Concluding remarks	578
	References	579

Part E Applications in Economic Sciences

E.1	The Impact of Human Capital on Regional Labor Productivity in Europe <i>Manfred M. Fischer, Monika Bartkowska, Aleksandra Riedl, Sascha Sardadvar and Andrea Kunnert</i>	
E.1.1	Introduction	585
E.1.2	Framework and methodology	586
E.1.3	Application of the methodology	592
E.1.4	Concluding remarks	595
	References	596
E.2	Income Distribution Dynamics and Cross-Region Convergence in Europe <i>Manfred M. Fischer and Peter Stumpner</i>	
E.2.1	Introduction	599
E.2.2	The empirical framework	601
E.2.3	Revealing empirics	608
E.2.4	Concluding remarks	622
	References	623
	Appendix	626

E.3	A Multi-Equation Spatial Econometric Model, with Application to EU Manufacturing Productivity Growth <i>Bernard Fingleton</i>	
E.3.1	Introduction	629
E.3.2	Theory	630
E.3.3	Incorporating technical progress variations	632
E.3.4	The econometric model	637
E.3.5	Model restriction	639
E.3.6	The final model	642
E.3.7	Concluding remarks	644
	References	645
	Appendix	647

Part F Applications in Environmental Sciences

F.1	A Fuzzy k -Means Classification and a Bayesian Approach for Spatial Prediction of Landslide Hazard <i>Pece V. Gorsevski, Paul E. Gessler and Piotr Jankowski</i>	
F.1.1	Introduction	653
F.1.2	Overview of current prediction methods	655
F.1.3	Modeling theory	658
F.1.4	Application of the modeling approach	666
F.1.5	Concluding remarks	679
	References	680
F.2	Incorporating Spatial Autocorrelation in Species Distribution Models <i>Jennifer A. Miller and Janet Franklin</i>	
F.2.1	Introduction	685
F.2.2	Data and methods	687
F.2.3	Results	691
F.2.4	Concluding remarks	697
	References	699
F.3	A Web-based Environmental Decision Support System for Environmental Planning and Watershed Management <i>Ramanathan Sugumaran, James C. Meyer and Jim Davis</i>	
F.3.1	Introduction	703
F.3.2	Study area	704
F.3.3	Design and implementation of WEDSS	705
F.3.4	The WEDSS in action	712
F.3.5	Concluding remarks	715
	References	716

Part G Applications in Health Sciences

G.1	Spatio-Temporal Patterns of Viral Meningitis in Michigan, 1993-2001	
	<i>Sharon K. Greene, Mark A. Schmidt, Mary Grace Stobierski and Mark L. Wilson</i>	
G.1.1	Introduction	721
G.1.2	Materials and methods	723
G.1.3	Results	725
G.1.4	Concluding remarks	730
	References	734
G.2	Space-Time Visualization and Analysis in the Cancer Atlas Viewer	
	<i>Dunrie A. Greiling, Geoffrey M. Jacquez, Andrew M. Kaufmann and Robert G. Rommel</i>	
G.2.1	Introduction	737
G.2.2	Data and methods	739
G.2.3	Results	742
G.2.4	Concluding remarks	750
	References	751
G.3	Exposure Assessment in Environmental Epidemiology	
	<i>Jaymie R. Meliker, Melissa J. Slotnick, Gillian A. AvRuskin, Andrew M. Kaufmann, Geoffrey M. Jacquez and Jerome O. Nriagu</i>	
G.3.1	Introduction	753
G.3.2	Data and methods	755
G.3.3	Features and architecture of Time-GIS	757
G.3.4	Application	759
G.3.5	Concluding remarks	765
	References	766
	<i>List of Figures</i>	769
	<i>List of Tables</i>	779
	<i>Subject Index</i>	785
	<i>Author Index</i>	793
	<i>Contributing Authors</i>	805