

Contents

	.....	ix
Series Preface	.....	xiii
1 Introduction		1
1.1 Why geostatistics?	.....	1
1.1.1 Generalizing	.....	3
1.1.2 Description	.....	5
1.1.3 Interpretation	.....	5
1.1.4 Control	.....	6
1.2 A little history	.....	6
1.3 Finding your way	.....	8
2 Basic statistics		11
2.1 Measurement and summary	.....	11
2.1.1 Notation	.....	12
2.1.2 Representing variation	.....	13
2.1.3 The centre	.....	14
2.1.4 Dispersion	.....	15
2.2 The normal distribution	.....	17
2.3 Covariance and correlation	.....	18
2.4 Transformations	.....	19
2.4.1 Logarithmic transformation	.....	19
2.4.2 Square root transformation	.....	20
2.4.3 Angular transformation	.....	20
2.4.4 Logit transformation	.....	20
2.5 Exploratory data analysis and display	.....	21
2.5.1 Spatial aspects	.....	22
2.6 Sampling and estimation	.....	23
2.6.1 Target population and units	.....	27
2.6.2 Simple random sampling	.....	28
2.6.3 Confidence limits	.....	29
2.6.4 Student's t	.....	30
2.6.5 The χ^2 distribution	.....	30
2.6.6 Central limit theorem	.....	31
2.6.7 Increasing precision and efficiency	.....	32
2.6.8 Soil classification	.....	34
3 Prediction and interpolation		37
3.1 Spatial interpolation	.....	37
3.1.1 Thiessen polygons (Voronoi polygons, Dirichlet tessellation)	.....	38
3.1.2 Triangulation	.....	38
3.1.3 Natural neighbour interpolation	.....	39

3.1.4	Inverse functions of distance	40
3.1.5	Trend surfaces	40
3.1.6	Splines	42
3.2	Spatial classification and predicting from soil maps	42
3.2.1	Theory	43
3.2.2	Summary	45
4	Characterizing spatial processes: the covariance and variogram	47
4.1	Introduction	47
4.2	A stochastic approach to spatial variation	48
4.2.1	Random variables	48
4.2.2	Random functions	49
4.3	Spatial covariance	50
4.3.1	Stationarity	52
4.3.2	Ergodicity	53
4.4	The covariance function	53
4.5	Intrinsic variation and the variogram	54
4.5.1	Equivalence with covariance	54
4.5.2	Quasi-stationarity	55
4.6	Characteristics of the spatial correlation functions	55
4.7	Which variogram?	59
4.8	Support and Krige's relation	60
4.8.1	Regularization	62
5	Estimating the variogram	65
5.1	Estimating semivariances and covariances	65
5.1.1	The variogram cloud	65
5.1.2	Average semivariances	66
5.1.3	The experimental covariance function	72
5.1.4	Drift and trend	74
5.2	Reliability of the experimental variogram	78
5.2.1	Statistical distribution	78
5.2.2	Sample size and design	85
5.2.3	Sample spacing	92
5.3	Theory of nested sampling and analysis	93
5.3.1	Link with regionalized variable theory	94
5.3.2	Case study: Youden and Mehlich's survey	96
5.3.3	Unequal sampling	98
5.3.4	Case study: Wyre Forest survey	99
5.3.5	Summary	103
6	Modelling the variogram	105
6.1	Limitations on variogram functions	106
6.1.1	Mathematical constraints	106
6.1.2	Behaviour near the origin	107
6.1.3	Behaviour towards infinity	108
6.1.4	Drift and trend	109
6.2	Authorized models	109
6.2.1	Unbounded random variation	109
6.2.2	Bounded Models	111
6.3	Combining models	121
6.4	Periodicity	122
6.5	Anisotropy	126

6.6	Fitting models	127
6.6.1	What weights?	131
6.6.2	How complex?	131
7	Spectral analysis	135
7.1	Linear sequences	135
7.2	Gilgai transect	136
7.3	Power spectra	138
7.3.1	Estimating the spectrum	139
7.3.2	Smoothing characteristics of windows	143
7.3.3	Confidence	145
7.4	Spectral analysis of the Caragabal transect	146
7.4.1	Bandwidths and confidence intervals for Caragabal	146
7.5	Further reading on spectral analysis	147
8	Local estimation or prediction: kriging	149
8.1	General characteristics of kriging	149
8.2	Theory of ordinary kriging	150
8.3	Weights	154
8.4	Examples	155
8.4.1	Kriging at the centre of the lattice	155
8.4.2	Kriging off-centre in the lattice and at a sampling point	164
8.4.3	Kriging from irregularly spaced data	166
8.5	Neighbourhood	167
8.6	Ordinary kriging for mapping	169
8.7	Case study	170
8.7.1	Summary	173
8.8	Regional estimation	176
8.9	Simple kriging	178
8.10	Lognormal kriging	179
8.11	Universal kriging	181
8.12	Optimal sampling for mapping	183
8.12.1	Isotropic variation	185
8.12.2	Anisotropic variation	187
8.13	Other kinds of kriging	188
8.14	Cross-validation	189
8.14.1	Scatter and regression	191
9	Cross-correlation, coregionalization and cokriging	193
9.1	Introduction	193
9.2	Estimating and modelling the cross-correlation	196
9.2.1	Intrinsic coregionalization	198
9.3	Example: CEDAR Farm	200
9.4	Cokriging	202
9.4.1	Is cokriging worth the trouble?	205
9.4.2	Example of benefits of cokriging	207
9.5	Principal components of coregionalization matrices	208
9.6	Pseudo-cross-variogram	217
10	Disjunctive kriging	219
10.1	Introduction	219
10.2	The indicator approach	222

10.2.1	Indicator coding	222
10.2.2	Indicator variograms	224
10.3	Indicator kriging	225
10.4	Disjunctive kriging	227
10.4.1	Assumptions of Gaussian disjunctive kriging	227
10.4.2	Hermite polynomials	228
10.4.3	Disjunctive kriging for a Hermite polynomial	230
10.4.4	Estimation variance	231
10.4.5	Conditional probability	232
10.4.6	Change of support	233
10.5	Case study	233
10.6	Other case studies	239
10.7	Summary	242

Appendix A Aide-mémoire for spatial analysis 243

A.1	Introduction	243
A.2	Notation	243
A.3	Screening	243
A.4	Histogram and summary	244
A.5	Normality and transformation	245
A.6	Spatial distribution	246
A.7	Spatial analysis: the variogram	246
A.8	Modelling the variogram	248
A.9	Spatial estimation or prediction: kriging	249
A.10	Mapping	250

Appendix B Genstat instructions for analysis 251

B.1	Summary statistics	251
B.2	Histogram	252
B.3	Cumulative distribution	252
B.4	Posting	253
B.5	The variogram	253
B.5.1	Experimental variogram	253
B.5.2	Fitting a model	254
B.6	Kriging	254
B.7	Control	255

References 257

Index 265