

R. Webster, M.A. Oliver: Geostatistics for Environmental Scientists

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This book is a revised and updated edition of the successful first edition that was published in 2001. A superficial comparison with the 2001 edition shows that the book is longer (315 instead of 271 pages) and the front cover is restyled with a modern, more colorful jacket. Does the face-lift also apply to what's inside? The answer is a partial yes.

The additional pages include a new chapter on spatial stochastic simulation. This is an important addition, because it was the main subject missing from the first edition. Further comparison with the first edition also shows that the variogram chapters have been reordered, though their content remains essentially unchanged. More attention is paid to kriging in presence of a trend, and a section on residual maximum likelihood estimation is included, which was completely absent from the first edition. Otherwise, the second edition is much like the first, with only marginal modifications and references to recent work added. Indeed, it would be odd if a book on introductory geostatistics would change very much in six years' time.

The book has 12 chapters, in which the standard order of presenting geostatistics is followed. The introduction explains the need for geostatistics, gives a historic account, and outlines the rest of the book. Chapter 2 presents basic statistics and Chapter 3 discusses deterministic interpolation techniques. Deterministic methods cannot represent the complex natural variation and do not produce a measure of interpolation error. These limitations motivate the use of a stochastic representation of reality. Chapters 4, 5, and 6 introduce regionalized variable theory, the experimental variogram, variogram modeling, and the reliability of the experimental variogram. A useful extension here would have been a discussion on uncertainty quantification

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of variogram model parameters, a subject which has significantly advanced in recent years. Chapter 7 makes a diversion to spectral analysis, which has merit for cases in which there is periodicity. A great diversity of kriging techniques are explained in Chapters 8 to 11, with much attention to ordinary kriging, universal kriging, factorial kriging, cokriging, and disjunctive kriging. Chapter 8 also addresses optimal sampling for mapping. This part seems somewhat outdated because it builds on work published in the 1980s and does not include later work that uses spatial simulated annealing and recent work that simultaneously optimizes sampling for mapping and variogram estimation. The book concludes with a chapter on stochastic spatial simulation, in which the differences with kriging are clearly explained and a comprehensive overview of simulation techniques is given. Appendix A summarizes the steps of a geostatistical analysis in a recipe-like fashion, and Appendix B provides GenStat code for most of the examples given in the book. The data sets can be downloaded from the book website, which also gives all of the maps in color.

The new chapter on spatial stochastic simulation begins with noting that kriging produces a smoothed representation of reality. Simulation is different and produces surfaces that preserve all of the variation in the data. However, the price of this is that the variance of the difference between the true and simulated value is twice that of the difference between the true and kriged value; simulation is not useful if the purpose is estimation. Instead, a suite of simulations can be used to provide a measure of the interpolation uncertainty, to construct confidence intervals of variogram estimates and to empirically derive multi-point statistics. Simulation is also essential for Monte Carlo uncertainty propagation analyses, but this is not mentioned. The chapter describes LU-decomposition, sequential Gaussian simulation, simulated annealing and the turning bands technique, and explains the difference between unconditional and conditional simulation. It does not state that the mean and variance of a large number of simulations may approximate the kriging mean and variance, thus missing the opportunity to rectify a common misunderstanding.

The book fits well in the Wiley series on Statistics in Practice, which aims to outline the practical use of statistical techniques in a wide range of applications, among others the Earth and Environmental Sciences. Although the use of mathematics and statistics is abundant and readers are assumed to be familiar with matrix notation and integral calculus, it is not too difficult for quantitative environmental scientists. The appealing writing style, pleasant use of symbols, clear explanations, abundant examples, and numerous tips for practitioners make it an excellent textbook. I have successfully used it myself in teaching introductory geostatistics to physical geography students. In fact, the book goes beyond an introduction because advanced geostatistical topics, such as regularization theory, REML estimation, the linear model of coregionalization, and disjunctive kriging, are presented as well. These topics can be skipped in an introductory course.

The authors are soil scientists, which is made apparent in the book. All examples are taken from soil science, and in the methodological sections ‘soil’ is written where ‘environment’ should have been. Few readers will find this disturbing, but undoubtedly the book would have been more convincing to environmental scientists if it had been less biased towards soil science. Nonetheless, the authors’ didactic skills combined with their decades of experience in applied geostatistics make this book an

excellent text for beginning practitioners and students. Reading it from cover to cover reminded me of the start of my own career in geostatistics, now more than 20 years ago. I learned the trade by studying the series of papers on geostatistics published by the authors in the *Journal of Soil Science*. I could not think of a better way to learn about geostatistics. We should be grateful that the same opportunity is given to the next generation of environmental geostatisticians through this book.

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