A.E. Gelfand, P.J. Diggle, M. Fuentes, P. Guttorp (eds.): Handbook of spatial statistics. Book review

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Book review on

Handbook of Spatial Statistics edited by A.E. Gelfand, P.J. Diggle, M. Fuentes and P. Guttorp

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Statisticians working in the field of spatial statistics and scientists analyzing and modeling spatial data have used Noel Cressie's celebrated *Statistics for Spatial Data* (1993) as *the* reference for almost 20 years. The *Handbook of Spatial Statistics* edited by Gelfand, Diggle, Fuentes and Guttorp is, in my opinion, the strongest candidate for being its worthy successor.

The edition of Cressie's *Statistics for Spatial Data* goes back to a time, unknown to the youngest, before the explosion of the use of MCMC methods coupled with the Bayesian paradigm for modeling environmental and ecological data and before the availability of cheap high-speed computers on every desktop. Since then, the field of spatial statistics has been enriched with important contributions, in particular in the field of asymptotic theory for geostatistics, model based geostatistics and hierarchical modeling, marked point processes and spatio-temporal processes. The time has come for a new reference book in spatial statistics. This *Handbook* remarkably achieves this aim.

This *Handbook* is a project directed by four outstanding researchers in the field of spatial statistics. It assembles a collection of 31 contributions, each of which was written by one of the leading figures in its respective field. These contributions are organized in six parts. Three parts correspond to the traditional main branches of spatial statistics: continuous variations for point referenced data, discrete spatial variations, including lattice and areal unit data, and spatial point patterns. Each of them combine, in a unique assemblage, contributions on theoretical background, state-of the art methodology for estimation and spatial prediction. They are illustrated with relevant and interesting examples. To these, the editors added an excellent section on spatio-temporal processes. A last section contains "additional topics" on multivariate spatial processes and misaligned data.

In an original way, the editors also included an excellent historical introduction (written by P. Diggle) detailing the evolution of the field. A specificity of spatial statistics is that it was pioneered by scientists working in different areas of applications (agriculture with R. Fisher, the mining industry with G. Matheron and forestry with B. Matérn), before being brought to the statistical community by J. Besag and B. Ripley. This chapter is a rare opportunity to offer a full recognition to the work of these pioneers.

The second part on continuous spatial variations starts with a theoretical background on continuous stochastic processes and classical geostatistical methods. It then contains contributions on subjects

mainly developed in the 1990s and later that are, to my knowledge, gathered together for the first time. These include, among others, contributions on asymptotics (both for the estimation of the covariance parameters and for spatial prediction), hierarchical models, nonstationary processes, monitoring network design and non Gaussian models. The last chapter on non-Gaussian and non-parametric models for continuous spatial data presents matters that are rarely found in general books on spatial statistics.

The third part deals with discrete spatial variations, a topic that has received considerable attentions recently. The first two contributions, written by H. Rue and L. Held are essentially a shorter, yet very clear and comprehensive, version of the monograph by the same authors (Rue and Held, 2005). It also contains one chapter on disease mapping and a last chapter on spatial econometrics. Spatial statistics have very much been oriented towards environmental, ecological and health related applications, while geographical and economical applications received much less attention. This contribution is thus a great opportunity for opening spatial statisticians to new fields of applications.

The fourth part is devoted to spatial point processes. It starts with contributions presenting the theoretical background, the main point process models, nonparametric and parametric methods, and marked point processes. In addition to these expected chapters, there is a chapter on “Modeling Strategies” by A. Baddeley. It is specifically targeted to spatial point processes, but questions such as “Do my data belong to a known domain, or are their limits to be estimated from the data?” could also be relevant to the “geostatistical” data considered in the second part (think of a pollution plume for example). As a matter of fact, the practice of statistics today is as much a question of modeling as a question of mathematical ability. Paradoxically, reading this excellent chapter left me somewhat frustrated at not having the possibility to read its “continuous spatial variation” counterpart. This part ends with a chapter on point processes in spatial epidemiology.

The fifth part presents some very recent material on spatio-temporal modeling, including some topics that have never been presented together in a unified fashion such as spatio-temporal point processes, spatial trajectories and spatial data assimilation. The editors are to be congratulated for having brought these topics together in such a nicely unified framework.

A last section contains “additional topics” on multivariate spatial processes and misaligned data, spatial aggregation and the detection of significant spatial gradients, a problem also called “wombling.” One could argue that they could have been made part of the previous parts, but this is simply a matter of taste.

The editorial quality of the book is absolutely remarkable. The editors made a real effort to unify notation and to provide an integrated and unified view of the field, with as many cross-references between chapters as necessary. Contributions are very clearly written. They avoid unnecessary technicalities, pointing instead to useful references. They are illustrated with many examples and case studies. In some chapters, R or WinBugs code is made available.

I strongly recommend *The Handbook of Spatial Statistics* as a textbook for an advanced class in spatial statistics, and as a reference book for anyone dealing with spatial data. It will definitely be one of my favorite books in the field for years to come, and I am convinced that it will be the case for many scientists. Considering the time drift and the environmental covariates, and after having

carefully estimated the space-time covariance, my best unbiased prediction is a very bright future for this book.

References:

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