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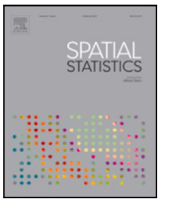

Review of Sujit Sahu's "Bayesian modeling of spatio-temporal data with R"

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Sujit Sahu has been prolific at writing papers and creating R packages for spatio-temporal modelling. His book is *Bayesian Modeling of Spatio-Temporal Data with R* is an informative and insightful cumulation of these efforts. The book fulfils three roles: an introduction to spatio-temporal data analysis; a detailed reference text on Bayesian computation for spatio-temporal models; and a comprehensive vignette for the accompanying R package `bmstdr`. An elegant web site contains a full set of code for reproducing the analyses in the book. This book is a useful "beyond the basics" resource for anyone wanting to use random-effects models for solving scientific problems involving spatio-temporal data. The book has 12 chapters plus appendices and feels like longer text than the 400 pages it actually has. It is very well structured as a reference text and a reasonably knowledgeable statistician could absorb most sections without having read the previous material. Specifically, theory and computational methods are covered thoroughly but it is possible to read the more applied sections treating the inferential algorithm as a black box.

There are extensive examples which consider both spatial prediction and using inference on model parameters to understand the underlying physical process.

The second chapter, "Jargon of spatial and spatio-temporal modeling" is a very helpful overview of topics related to spatial statistics, covering Gaussian processes, stationary covariance functions, and spatial prediction (and more besides). The language is kept non-technical, no specific statistical knowledge is assumed although the material ramps up quickly. A reader with some familiarity with hierarchical models or time series analysis would quickly be able to acquire a solid background in spatio-temporal models.

The third chapter covers exploratory data analysis, producing basic maps and data plots as well as computing simple spatial correlation statistics. Minimal use is made of R's spatial data types or on and spatial operations such projecting or overlaying points on polygons. This is understandable as the focus of the book is on modelling and such material is well provided for elsewhere. Some minor updates to the online code will be needed when the venerable `spdep` and `rgdal` packages are retired. Maps and figures are produced using `ggplot`.

The two following chapters, 4 and 5, cover the fundamentals of Bayesian inference and method of Bayesian computation. This includes different types of MCMC, INLA, and computing model choice criteria (i.e. DIC). The 80 pages in these chapters will be valuable to theorists but are not essential for following the remainder of the book.

Chapters 6 and 7 covers the linear Geostatistical model and related spatio-temporal models respectively. Spatial models have Mat'ern correlation functions, and the spatio-temporal chapter builds up to a model with a separable covariance function which is the product of a Mat'ern in space and an exponential/AR(1) in time. A Metropolis and Gibbs MCMC algorithm for each model is presented in detail and fit using the author's `spBayes` and `spTimer` packages. The models are also fit with a Hamiltonian MCMC using Stan as well as with INLA and the SPDE approximation of the Mat'ern. The `bmstdr` package provides a unified front-end, with an option `package = 'stan'` or `package = 'inla'` being all that is required to change the back-end. This feature is a major strength of the book and software, clearly demonstrating that a statistical model is separate from the algorithm used to fit it. Chapters 8 and 9 show examples of modelling and spatial prediction for a several environmental datasets. Model checking and model selection are considered in detail.

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Chapters 10 and 11 concern area-level models, where spatial dependence is determined by areas being adjacent to one another (as opposed to distance between them). The focus also switches from Gaussian data to Poisson or Binomial responses, which reflects the typical application of these models being counts if a health outcome observed in administrative areas. The final spatio-temporal model has separable covariance with the spatial covariance specified as a conditional autoregression and temporal dependence modelled with an AR(1). Here again `bmstdr` is a front-end with INLA or `CARBayesST` two possible back-ends. Again, a number of examples are given in considerable detail.

The one topic that could have been given more attention is prior distributions. It is all-too easy to specify prior distributions which are unintentionally informative, such as standard deviations which are kept away from zero or range parameters which force a high degree of spatial dependence. Default priors are used in many of the examples. Model validation and comparison is given the attention it deserves throughout the book, more on prior sensitivity would have been welcome. Geographers will object to many of the maps, but there are many other texts devoted to spatial data manipulation and visualization in R.

The book's greatest contribution is providing useable and stable methods (and software) for fitting spatio-temporal models, these tools provide useful solution to a range of problems. Some analyses are more computationally intensive than others (the Stan implementation is the most time consuming), but the examples all run on moderately powered computers within a reasonable amount of time. Further, the text contains all of the background material required for understanding the models and inference methods. The author has shown that a fairly broad class of spatio-temporal problems can now be dealt with easily, and this text provides a path for learning a range of spatio-temporal methods quickly.