

and well organized. Two appendixes provided at the end of the text explain the installation of R and provide a quick tutorial on the use of R. In addition, a handful of exercises are provided at the end of each chapter, the level of which are similar to those in the text of Muller and Fetterman (2002). A "how to" text on R would be a helpful supplement to this text. Overall, *Linear Models With R* is well written and, given the increasing popularity of R, it is an important contribution.

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**Time Series Analysis by State Space Methods**, by J. DURBIN and S. J. KOOPMAN, New York: Oxford University Press, 2004, ISBN 0-19-852354-8, xvii + 253 pp., \$70.00.

This book presents a statistical approach to the type of so-called "state-space" models used in time series econometrics. The work is in the spirit of the atheoretical correlation based modeling popularized by the famous text of Box and Jenkins (1976). Part I deals with the linear Gaussian state-space model. Part II presents a strange multiplicative nonlinear model that is not justified by any scientific model based on theory. The authors claim that their modeling approach is very general. They provide several examples of this nonlinear approach in Chapter 14, but I find these examples unconvincing. The space of nonlinear models is uncountable, and unless the model is based on a nonlinear differential equation derived from scientific theory, the only way to prove that the estimated model is of any value is to show how it forecasts. A forecasting methodology for calibrating a nonlinear model is not simple, to say the least.

The authors never discuss where the state-space model comes from. A state-space parametric model is basically a linear dynamical system. The mathematical model underlying dynamical system is a system of finite-order linear differential equations with constant coefficients. The behavior of these system for  $t > t_0$  is uniquely determined if an appropriate set of initial conditions at time  $t_0$  is specified. The solution is a linear combination of damped sinusoids. A good treatment of such systems and their discrete-time sampled data versions was given by Tretter (1976, chap. 6). Tretter also provided a better treatment of the Kalman filter than is provided in this book.

The authors discuss continuous-time state-space models in Section 3.10. They appear to be ignorant of the differential equation mathematics underlying linear dynamical systems. The output of a linear dynamical system driven by an input, either deterministic or random, is a convolution of the impulse response of the system and the input. But the fundamental issues of sampling of continuous time processes must be dealt with. Aliasing is an important aspect of discrete-time sampling of a process. There are no references to aliasing, bandwidth, frequency, or sampling in the subject index of this book. There also is no discussion of the intimate connection between time and frequency methods.

This book perpetuates the false concept that arose with the success of the Box and Jenkins text that it is possible to adequately model a time series using a parametric model that is not derived from any theory using statistical time domain manipulations of the data.

I am teaching a graduate course in time series next semester cross-listed with Economics and Political Science. I will cover the Kalman filter and linear dynamical systems in both continuous and discrete time. I will not put this book on reserve for that course.

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Box, G., and Jenkins, G. (1976), *Time Series Analysis, Forecasting and Control*, San Francisco: Holden Day.  
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**Chaos and Time-Series Analysis**, by Julien Clinton SPROTT, New York: Oxford University Press, 2003, ISBN 0-19-850839-5, xx + 507 pp., \$120.00.

The theme of this book is the detection and characterization of chaos in dynamical systems, based on measurements of the system state as a function of time. It would be appropriate for a physics course for either advanced undergraduates or graduate students. With supplementary material (perhaps from Sprott 1993, out of print but available at <http://sprott.physics.wisc.edu/sa.htm>), it could form the basis of a course in applied mathematics or mathematical physics.

This is a very ambitious book, covering a huge amount of material. The first eight chapters are a comprehensive introduction to dynamical systems, emphasizing concepts, and practical matters with the necessary mathematics provided as needed. Chapter 9 begins the treatment of time series, followed by clear and detailed discussions of nonlinear prediction and noise reduction. After an introduction to fractals come chapters on the computation of fractal dimension, fractal measures and multifractals, and nonchaotic fractal sets.

For certain research interests, the treatment of spatiotemporal chaos and complexity in the final chapter is rather superficial. This brief discussion does cover the generation of complexity and organization in the evolution of sample spatially extended systems, but does not do justice to the theme of the book: how such systems can be studied with time-series analysis, for example, using symbolic dynamics and related time-series approaches, such as those developed by Crutchfield and coworkers (Crutchfield and McNamara 1987; Young and Crutchfield 1993).

Finally, I believe that more warnings should be given to the person interested in the actual analysis of time-series data. Especially in astronomy, many researchers went wrong by naively assuming that estimation of smallish, non-integer fractal dimensions implied the presence of chaotic dynamics. The articles by Osborne and Provenzale listed in the book's bibliography, and one by Eckmann and Ruelle (1992), point out the pitfalls that face the analyst of finite, noisy data.

But these are very minor objections. On the whole, this is a masterful volume that will be very useful for students at various levels, as well as for researchers. I believe that this is the first book to systematically cover analysis of time-series data from chaotic dynamical systems, and thus it is a very welcome book indeed.

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**Statistical Analysis of Stochastic Processes in Time**, by J. K. LINDSEY, Cambridge, U.K.: Cambridge University Press, 2004, ISBN 0-521-83741-3, xiv + 338 pp., \$75.00.

It is always nice to learn something about a field with which one is otherwise unacquainted, but it is especially nice to do so without exerting oneself. The au-

thor has exerted himself mightily so that the reader of this delightful book does not have to. This is not a book for the novice; it requires a nontrivial knowledge of statistics at the level of, say, an advanced undergraduate. Yet it provides a concise introduction to and exposition of a wide variety of topics.

The book comprises three parts. Part I contains a pair of introductory chapters: "What Is a Stochastic Process?" and "Basics of Statistical Modelling." Part II surveys "Categorical State Space" in a half-dozen chapters: "Survival Processes," "Recurrent Events," "Discrete-Time Markov Chains," "Event Histories," "Dynamic Models" (e.g., hidden Markov models and overdispersed series of counts), and "More Complex Dependencies" (e.g., birth processes and marked point processes). Part III surveys "Continuous State Space" in another half-dozen chapters: "Time Series," "Diffusion and Volatility," "Dynamic Models" [e.g., hidden Markov models (again) and Kalman filtering], "Growth Curves," "Compartment Models," and "Repeated Measurements." Naturally, reading a single chapter cannot make one an expert, but the author does a remarkable job of presenting some basics of each field in an interesting and useful fashion.

Each chapter provides some theory, although this can be skipped without losing continuity. In addition, each chapter offers several examples, and the range of examples throughout the book is notable: botany, criminology, demography, finance, medicine, psychology, and more. The book's website provides the data and R code for all of these examples, as well as most of the chapter exercises. This is particularly useful, because the code makes clear how the models presented in the book can be estimated in practice.

Perhaps this book could be used for some sort of survey course, but its real value would be in exposing researchers to fields with which they were unfamiliar. Any person who does research in any area of time series will enjoy this book, because it will open up new vistas and new ways of approaching problems, as well as provide sufficient reference material to follow up any interesting leads. Anyone who ever wondered what survival processes are all about will spend an enjoyable couple of hours with Chapter 3—and several more hours if he has R on his computer and wants to play with the models about which he has read. The same can be said of all the other chapters in this well-written, enjoyable book.

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**Time Series Analysis and Inverse Theory for Geophysicists**, by David GUBBINS, Cambridge, U.K.: Cambridge University Press, 2004, ISBN 0-521-52569-1, xv + 255 pp., \$50.00 (P).

This book is clearly intended as a text aimed at geophysics students at both the undergraduate and beginning graduate level. It is organized in three parts. Part I is devoted to processing and includes some material on the discrete Fourier transform. According to the author, this material has been used for a course in time series for geophysics students at the University of Leeds. Part II is on inversion and likewise has been used for a course on geophysical inversion. Part III consists of additional example applications. Each chapter is followed by a set of exercises, many of which will require analysis of a dataset. Part I mostly uses a package called *pitsa* that is available for free downloading from a site listed in Appendix 7. Part II also uses the GNU *octave* and *gnuplot*. It is likely that R and some of its "packages" could be used in lieu of the other GNU programs. The datasets used in the book are also freely downloadable.

Geophysical analysis makes extensive use of seismograph or seismometer data, which are continuous data collected over time. The data will vary in magnitude as well as in frequency. Although the data are initially continuous, they are often recorded in digital form. The digitized data are then "processed" in various ways. The processed data still do not represent direct measurements on features of the earth or the subsurface, or events such as earthquakes. The next step is "inversion," a way of transforming the data into more easily interpretable physical quantities. The distinction between "true inversion" and "parameter estimation" is briefly discussed in Chapter 1. Only parameter estimation is discussed in this text.

There are four chapters in Part I: Chapter 2, "Mathematical Preliminaries: The  $z$  and Discrete Fourier Transforms"; Chapter 3, "Practical Estimation of Spectra"; Chapter 4, "Processing of Time Sequences"; and Chapter 5, "Processing 2-D Data." The latter includes a discussion of traveling waves. Here 2-D means distance and time. Both filtering and inverse filtering are presented.

There are four chapters in Part II. Chapters 6 and 7 are concerned with linear parameter estimation. Let  $\mathbf{d}^T = (d_1, \dots, d_D)$  be a data vector, let  $\mathbf{m}^T =$

$(m_1, \dots, m_p)$  be a parameter vector, and let  $\mathbf{e}^T = (e_1, \dots, e_D)$  be a vector of errors corresponding to the data vector. Then the *forward discrete linear problem* can be written in the form  $\mathbf{d} = \mathbf{A}\mathbf{m} + \mathbf{e}$ , where  $\mathbf{A}$  is a matrix independent of both the data and the model. This is also referred to as the *equations of condition*. The weighted linear sums might be replaced by integrals with a kernel in the continuous case. This, of course, looks like the usual regression model, but most of the ideas and discussion on regression that might be found in the text of Myers (1990) is absent here. In particular, the treatment of the various diagnostics and inferential techniques are missing. The objective is to solve for the parameter vector. The least squares solution of overdetermined problems and the effect of both linear and nonlinear transforms are discussed. The very important *resolution matrix* is discussed in connection with the underdetermined inverse problem. A nonlinear model would be of the form  $\mathbf{d} = \mathbf{f}(\mathbf{m}) + \mathbf{e}$ .

Chapter 8 discusses three broad approaches to nonlinear problems: *tricks* that work for specific examples; *forward modeling*, or brute force solution of the forward problem; and *linearization*, that is, replacing the nonlinear problem with a linear approximation. Chapter 9 is a brief digression to the linear continuous inverse problem. The Dirichlet condition, trade-off curve, and minimum norm solution are covered briefly.

Part III consists of three chapters: Chapter 10, "Fourier Analysis as an Inverse Problem"; Chapter 11, "Seismic Travel Times and Tomography"; and Chapter 12, "Geomagnetism."

Finally, there are seven appendixes covering Fourier series, the Fourier integral transform, Shannon's sampling theorem, linear algebra, vector spaces and function space, Lagrange multipliers and penalty parameters, and files for the computer exercises. Except for the last one, each appendix is simply a brief listing of definitions and principal results. The reader unfamiliar with these topics will not find the appendixes adequate, they do provide a summary of the prerequisite knowledge for the student/reader. Clearly, some computing experience is necessary; recall that *octave* is the GNU version of MatLab thus some programming experience is necessary.

The book's title may be a bit misleading for some readers; the treatment of time series is not much like what might appear in a beginning or intermediate level text on time series. There is no mention of the usual models (e.g., AR, MA, ARMA), and the autocorrelation function does not appear. This is partly because of the emphasis on digitized data. All integrals are assumed to be Riemann or improper Riemann (but convergence questions are ignored).

The reader is assumed to be somewhat familiar with geophysics and geophysics data. This is the part that may be new to a reader already familiar with time series and regression analysis. However, the applications and the discussion of geophysics data will be of interest to the statistician.

Each chapter has one or more "boxes," short, succinct summaries of the "recipes" for the various methods discussed within the chapter. On the whole, the book is quite readable and well organized. It is interesting to compare this book with the text of Menke (1989). It is approximately the same length and requires about the same prerequisite material. There is the implication that it has been also been used as a text, but there are no exercises and little or no discussion of the "processing" of data. FORTRAN codes are included in an appendix for the solution of the even-determined, underdetermined, and overdetermined linear inverse problems. *Time Series Analysis and Inverse Theory for Geophysicists* includes very little in the way of derivations, Menke's text somewhat more and with a stronger reliance on linear algebra and the use of the multivariate Gaussian distribution. In general, the datasets referenced by Menke are not easily accessible.

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**Bootstrap Techniques for Signal Processing**, by Abdelhak M. ZOUBIR and D. Robert ISKANDER, Cambridge, U.K.: Cambridge University Press, 2004, ISBN 0-521-83127-X, xiv + 217 pp., \$75.00.

This book serves as a handbook for engineers on the resampling method called "bootstrap," to analyze complicated data with little or no model assumption.