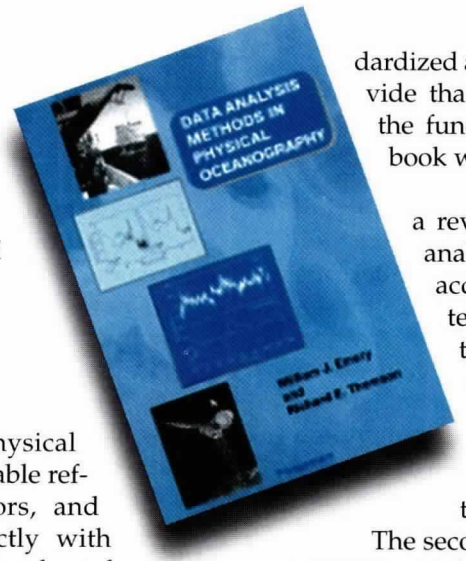
Data Analysis Methods in Physical Oceanography



By William J. Emery and Richard. E. Thomson. 400 pages. Elsevier Science Inc. ISBN 0-080-31434-1

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"Data Analysis Methods in Physical Oceanography" is a unique and valuable reference text for students, instructors, and researchers who either work directly with oceanographic data or need a working knowledge of data collection and analysis products. The book provides an unusual breadth of coverage with a rich oceanographic context. The traditional topics of probability, statistics, and time series analysis are combined with discussions of specialized, yet routinely applied, methods such as estimation of principal axes, computation of vertical normal modes, and rotary spectral analysis. Brief reviews of subjects not covered in traditional time series analysis texts, such as inverse methods, wavelets, and fractals, are also included. Several other gems, such as sections on dependent samples, error detection, and interpolation round out the presentation. Oceanographic context is provided by a large number of examples. All are from the geophysical sciences, and the vast majority are from physical oceanography. Thus, the reader may simultaneously learn about an analysis method, note how it performs when applied to real data, and gain exposure to relevant oceanographic phenomena (e.g. coastal trapped waves along the Australian coast or sea level oscillations in the western Pacific).

While the breadth of coverage is remarkable, there is, inevitably, a price to pay in terms of depth. By employing a "survey" approach to topics of widely varying complexity, the authors sacrifice the detail necessary to fully appreciate more difficult topics. The preface and jacket notes indicate that this is by design. The book is suggested as instructional material for a graduate-level oceanography course and as a general reference volume for oceanographic researchers. The content is well suited to both purposes, and could be a means of unifying the presentation of analysis methods to students. As the authors note in the preface, most oceanographic graduate programs have a "methods" course (discussing the measurement, calibration, processing and interpretation of geophysical data), but the material presented is not standardized and no (other) text exists which might provide that standardization. If adopted to provide the fundamental material for such courses, this book would serve the community well.

Interestingly, the book begins not with a review of background material relating to analysis methods, but with chapters on data acquisition and presentation. The first chapter provides a brief review of sampling theory followed by descriptions of sensors used for the measurement of temperature, salinity, pressure, sea-level, surface waves, currents, wind, and precipitation. The final two sections of the chapter introduce chemical tracers. The second chapter is the shortest (33 pages) and consists mainly of figures showing typical data presentation methods used in physical oceanography. Examples of vertical profiles, time series, contour maps, temperature-salinity diagrams, and various three-dimensional presentations are included.

Chapters three through five contain material more fundamental to the book's mission. The third chapter introduces statistical methods and provides the background necessary for succeeding chapters. All of the usual topics, including probability density functions, moments, regression, confidence intervals, and hypothesis testing appear. Subsections on editing and despiking techniques, interpolation, and bootstrap methods are useful additions. The fourth chapter concentrates on spatial analysis, and is principally a description of empirical orthogonal functions (EOFs) and vertical normal modes, with brief introductions to objective analysis and inverse methods. The fifth and last chapter is the longest (197 pages), and arguably the most successful, of the book. Titled "Time Series Analysis Methods", this chapter includes comprehensive coverage of fourier, harmonic, spectral, and cross-spectral analysis, along with subsections on digital filters, wavelets, and fractals. Appendices include a list of units and conversions, statistical tables and glossaries of commonly used statistical and oceanographic terms. A table of geophysical constants and summary of the properties of seawater would be welcome additions.

This book is not a substitute for rigorous texts in probability and statistics or time series and spectral analysis. I will not be removing my copies of Papoulis (1984) or Jenkins and Watts (1968) to make room on the bookshelf for this volume. While straightforward techniques such as complex demodulation or the method of least squares probably require no more than the few pages devoted to them, the same cannot be said for more complex topics such as inverse theory or wavelet analysis. Of course,

other references exist for such topics, but the citation of these supplemental sources is not always consistent. For example, Bennett's (1982) text and several important papers on inverse theory are cited, but two popular texts on wavelet analysis (Foufoula-Georgiou and Kumar, 1994; Strang and Nguyen, 1996) are not.

This book will have a place on the shelf, however, because its practical, almost folksy approach provides an appropriate complement to more rigorous, theoretical texts. A discussion of effective degrees of freedom and integral time scales, advice on the interpolation of gappy records, and a warning about interpreting a high degree of correlation in terms of cause and effect are examples of useful and important topics which are seldom included in text books. I found the practical approach most apparent, and perhaps most valuable, in the section on "Editing and Despiking Techniques". I cannot think of any other text in which non-random errors which are not representative of the true population (called "accidental errors" by the authors) are described, despite the fact that data processors deal with them routinely. Admitting that such errors exist leads to an interesting discussion of how (or whether) such "bad" points are eliminated. In particular, it is noted that this process is subjective and that "care must be taken not to reject important data points just because they don't fit ... our preconceived notion". This is an important issue which is seldom presented to students and often under-appreciated by researchers. I believe that much would be gained by expanding on this topic to include a description and some examples of what Irving Langmuir (1989) called "pathological science", being tricked into false results by a lack of understanding of how human beings can be led astray by subjective effects and wishful thinking.

The inclusion of material on oceanographic instrumentation and sampling techniques has some clear benefits, but also some drawbacks. As the authors note in the introduction, it is important for oceanographers to be aware of the capabilities and limitations of the equipment used to make field observations. This is particularly beneficial in cases where a student or researcher may be working with data from instruments that are unfamiliar. In an era when a wide variety of data sets can be obtained on CD-ROM and over the Internet, this situation arises more and more often. However, in some cases the authors take this concept too far. For example, it seems appropriate for the modern oceanographer to have a working knowledge of the profiling CTD, but it is not clear that the mechanical bathythermograph is of more than historical interest. Similarly, features like the nine-step protocol for preparing an Aanderaa RCM4 current meter, the cutaway view of an Argos Platform Transmit Terminal and the three pages describing acoustic releases do not seem particularly useful.

In any review of the rapidly changing field of instrumentation and observational techniques, it is relatively easy to find material that is missing or out of date. For example, a brief review reveals the following: the use of towed devices and autonomous vehicles for the measurement of water properties is not described. The section on Eulerian currents includes acoustic Doppler current profilers, but no mention of other acoustic Doppler methods which are rapidly gaining popularity. Recent advances in estimating precipitation using satellite methods and alternative approaches such as radar backscatter are not described. Finally, while the authors should be applauded for including brief sections on satellite-derived observations, it is surprising that the reader is not directed to background material on satellite remote sensing in books such as those by Maul (1985) and Stewart (1985).

In summary, this book is the most comprehensive and practical source of information on data analysis methods available to the physical oceanographer. The reader gets the benefit of extremely broad coverage and an excellent set of examples drawn from geophysical observations. The survey approach purposefully sacrifices depth of coverage in more complex topics for completeness. The initial chapters on data acquisition and presentation are a thoughtful addition, but coverage is uneven and the material is not essential to the primary mission of the book. Although very successful as a reference text for the data analyst, utility could be improved by more carefully selected citations and expanded appendices. The practical orientation and folksy style provide an excellent complement to traditional texts which take a more rigorous approach. The nature of the book is appropriately described by the jacket notes which extol the content as "... both a guide and an encyclopedia to modern data processing methods in the geophysical sciences". An instructor, a student, or a researcher in need of such a reference will not be disappointed

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Strang, G. and T. Nguyen, 1996: *Wavelets and Filter Banks.* Wellesley-Cambridge, Wellesley, 490 pp.

People and the Earth: Basic Issues in the Sustainability of Resources and Environment

By John J.W. Rogers and P. Geoffrey Feiss
360 pages. Cambridge University Press
ISBN 0-521-56028-4

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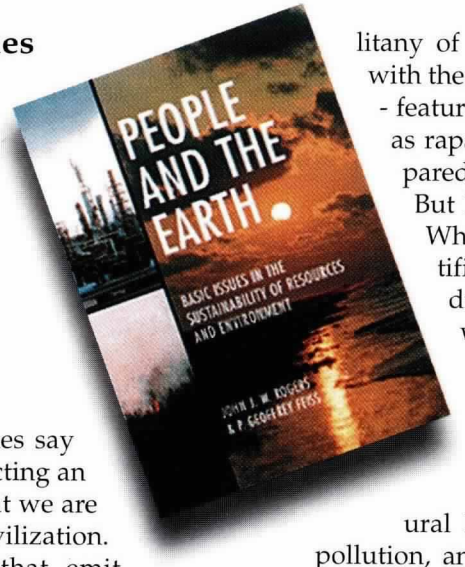

One dumb thing that scientists sometimes say about global warming is that we are conducting an experiment in the atmosphere. In fact, what we are conducting, or trying to conduct, is a civilization. Characterizing the economic activities that emit greenhouse gases as some kind of insane scientific experiment is to miss the most important part of the story. Global warming and other environmental problems are fundamentally economic problems. Physical scientists know next to nothing about economics. Actually, they know just about as much about economics as economists know about physical science. The difference is that, these days at least, physical scientists are not shy about holding forth on economic issues while economists are generally silent on physical science.

All this is to say that I was prepared to hate "People and the Earth" written by two geologists, John Rogers and P. Geoffrey Feiss. I was prepared for yet another litany of environmental doom and gloom, with the human race – the authors excepted - featured at best as heedless and at worst as rapacious. In other words, I was prepared for another "Earth in the Balance". But I didn't hate this book. I liked it. While it certainly focused on the scientific side of environmental issues, it did so in a balanced and informative way, avoiding apocalyptics and simplistic prescriptions.

The book consists of nine chapters, all but the last covering a broad area of environmental science: population, food, natural hazards, water, energy, minerals, pollution, and global change. The writing is lighthanded, the level undergraduate. There are lots of graphs, tables, and figures and a large number of boxes describing specific cases. Sprinkled throughout the text are "policy questions" aimed at provoking thought. Each chapter concludes with a number of problems, none very challenging, and a list of references.

I had a couple of quibbles. For example, the theory that the eruption of Santorini in 1628 BCE destroyed the Minoan civilization is no longer tenable. Also, biological oceanographers will be surprised to read that the nutrients supporting phytoplankton come from dead fish! But, all in all, this is a nice book and I recommend it.

Books Undergoing Review:

Coastal Ocean Prediction
Christopher N.K. Mooers, Editor
American Geophysical Union, Publisher

Global Ocean Science: Toward an Integrated Approach
National Research Council – Ocean Studies Board
National Academy Press, Publisher

Ocean, Ice and Atmosphere: Interactions at the Antarctic Continental Margin
Stanley Jacobs and Ray Weiss, Editors
The American Geophysical Union, Publisher

The Restless Sea: Exploring the World Beneath the Waters
By Robert Kunzig
W.W. Norton, Publisher

Tides: A Scientific History
By David Edgar Cartwright
Cambridge University Press, Publisher