

# Weather Cycles

## *Real or Imaginary?*

Written by William James Burroughs  
Second Edition, Cambridge University  
Press, 2003, 330 pages  
Hardcover: ISBN 0521820847, \$100 US  
Paperback: ISBN 0521528224, \$50 US

REVIEWED BY MICHAEL N. EVANS

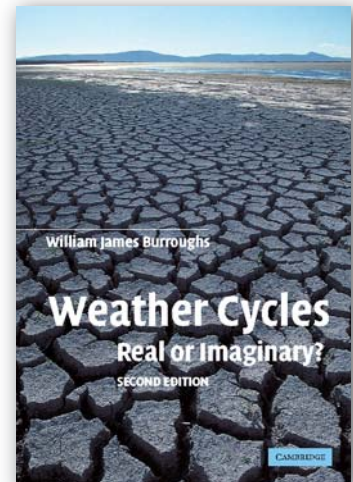
Are observed climate variations best described as cyclical, stochastic, or chaotic in nature? This is the essential question posed by W.J. Burroughs. Our confidence in climate predictions on time scales of seasons to centuries, including the global warming debate, depends on the answer. The book explores evidence and arguments for cyclical features in direct meteorological records such as temperature and precipitation, as well as indirect, or proxy, climate data derived from geological, biological, and economic data series. It then proceeds to lay out the physical and statistical mechanisms that may support the existence of these cyclicities when the observations are messy, indirect, incomplete, or simply don't span enough time.

This well-written, clearly illustrated and argued book, geared for everyone from climate-change scientist to layperson, forms a clear opinion, shot through with dry wit. With a few notable exceptions, much of the variability we see is likely stochastic or weakly chaotic, which explains our many failures to both diagnose stationary cyclicities in the climate system and use them for predictive purposes. The result has important implica-

tions for climate modelers, policy-makers, and voters. If the climate system is weakly chaotic, there may be underlying structure, albeit with limited predictability. It also means that familiar climatological patterns may be better described as regimes subject to abrupt changes in mean state and variability. The appearance of such changes may be sensitive to anthropogenic perturbations in ways we do not yet understand.

Published in 2003, the second edition is extensively revised from the 1992 edition in three important ways. First, there is an expanded introduction to statistical methods, notably wavelet analysis and singular spectrum analysis. These techniques have been more commonly applied since publication of the first edition, and are reasonably described as more applicable than classical Fourier-based analytical techniques for the study of short, noisy data sets with embedded quasiperiodicities. Statistics buffs and those who use statistics in the study of climatological and paleoclimatological data would do well to pore over the appendices before interpreting subtle signals in their own data.

Second, there is also a substantially expanded review of climate and paleoclimate data, which forms the first half of the book. This review is important, because in the last decade there has been an explosion in the amount and quality of paleoclimatic proxy climate data relevant to the question Burroughs has framed. Burroughs's expanded review is generally



well done. His one omission is discussion of the development of spatiotemporal data analysis techniques for reconstruction of climate fields from networks of climatological and paleoclimatological data, which received much attention in the mid-1990s. These techniques contain the implicit ability to extract periodicities and patterns common to disparate data series through eigenanalysis-based techniques, although not without significant assumptions and uncertainties; Burroughs would be well suited to review these techniques objectively.

In his third major revision to the text, Burroughs has expanded his review of the leading hypotheses put forward to explain the observed climate variability discussed in the second half of the book. Again, Burroughs has captured much of the new interest in climate dynamics across the international scientific community. The reviewed mechanisms include internal dynamical phenomena, external (solar) forcing, stochastic with memory and resonance, and chaos. Major physical mechanisms internal to the climate system, including tides, the Quasibiennial Oscillation (QBO), the

Madden-Julian Oscillation (MJO), the El Niño/Southern Oscillation (ENSO), the thermohaline circulation, and Earth's orbital variations are reviewed. External forcing, potentially caused by solar variability, is given an objective description. Finally, statistical explanations are explored: the possibility that it is all "noise," that it is noise with memory or nonlinear resonance, and that it is the result of low order chaos. Only a few cyclicities survive Burroughs' analysis: the annual cycle, the quasi-biennial oscillation, the El Niño-Southern Oscillation (ENSO), and perhaps a bidecadal cycle.

I found only a few features of this book with which to quibble. The use of the term "weather" in the title is not quite representative of the subject matter,

which is mainly concerned with climate changes on interannual and longer time scales. There are a few subtle referencing errors. Typographical errors (some new, others holdovers from the first edition) are regrettable. I found the observational summary tables (3.1, 4.2) difficult to parse and not entirely consistent with the text or my reading of the data. However, the overall point that most cycles are not well defined and appear to come and go, or shift frequencies, over the time period, remains well taken.

Most intriguing to me was Burroughs's suggestion of a chaotic framework for the observations and our predictive failures. He has produced a well-written, clearly illustrated review, which makes an important point. But

Burroughs stops short of fully developing chaos as a paradigm for his review of the extant climatological and paleoclimatological data. I only hope that he has done so to whet our appetites for a companion volume exploring this hypothesis, as was done so well by Paul Ormerod (*The Death of Economics*, 1994; *Butterfly Economics*, 1998) for economic and social phenomena. In the meantime, I will recommend this book to colleagues and friends interested in the science of climate change. ☒

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## Changing Sea Levels

### *Effects of Tides, Weather and Climate*

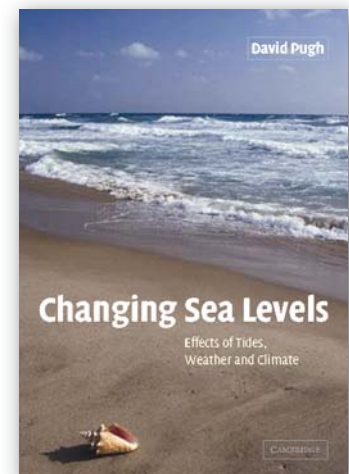
Written by David Pugh  
Cambridge University Press  
2004, 280 pages  
Hardcover: ISBN 0521825326, \$115 US  
Paperback: ISBN 0521532183, \$60 US

REVIEWED BY NICK HARVEY

*Changing Sea Levels: Effects of Tides, Weather and Climate* by David Pugh is a welcome addition to the literature, particularly because of the increasing debate over predictions for sea-level rise stimulated by deliberations and re-

ports of the Intergovernmental Panel on Climate Change (IPCC). This book is aimed at undergraduate students involved in interdisciplinary studies, although it will also be very useful for a variety of professionals such as coastal planners and engineers.

The book, which arose from Pugh's earlier (1996) volume, *Tides, Surges and Mean Sea-Level*, has been written in an informative and easy-to-read style in a deliberate attempt to reduce the number of statistics presented. Additional mathematical detail is given in an appendix



and on a related web site. The book is very well illustrated with clear black and white diagrams and photographs. In addition, eight of the more complex global diagrams have been reproduced in color

to make their interpretation easier. Overall, this is a very appealing text.

*Changing Sea Levels* is organized into nine chapters, each of which concludes with a series of questions related to that chapter and a useful guide to further reading on the topic. The first chapter begins by examining how sea level is actually measured. It includes a discussion of direct-measuring instruments, such as tide poles and float gauges; fixed sensors, such as acoustic and pressure sensitive systems; and satellite altimetry. This introductory chapter discusses the advantages, disadvantages, and accuracy of various techniques. It also provides a quality discussion on the use of satellite data, modern GPS technology, and the Global Sea Level Observing System (GLOSS).

Chapters 2 through 5 deal with the science of tidal generation. Chapter 2 examines tidal diversity, the gravitational forces, tidal patterns, and the influence of the geoid. Chapter 3 provides an outline of methods for tidal analysis and prediction, including the use and correction of satellite altimetry data. Chapters 4 and 5 examine tidal dynamics both in the open ocean and near the coast.

Having outlined tidal analysis and interpretation in earlier chapters, Chapter 6 then examines the factors influencing tides such as the weather, wind stress, and the creation of storm surges. Here Pugh provides the reader various regional examples of surge generation, including extra-tropical storms in the North Sea and the tropical cyclone surges in the Bay of Bengal. The chapter concludes by looking at tsunami generation and issues of flood risk and warning systems.

Chapter 7 addresses the topical issue of mean sea level (MSL), which has at-

tracted public interest through the debate on global climate change and possible future impacts it can have, such as increasing MSL and coastal flood risk. This chapter examines the nature of the historic tide-gauge record and explains the problems of deriving accurate MSL trends from the record, including annual and inter-annual changes, isostatic adjustment, and changes in water volume. Chapter 7 provides a strong link to the debate on climate-induced MSL rise and reinforces the point that sea-level measurements are “relative” and there is a need to identify the variations within the record in order to obtain data that can be compared between sites. Pugh discusses the importance of land movements due to a wide range of geological influences, but most importantly, the need for global isostatic adjustment of the data. This adjustment results from the fact that the global redistribution of ice and water following the last glacial has produced a differential response from the world’s coastlines. This subtle movement, however, is incorporated in tide-gauge data and needs to be removed in order to calculate meaningful MSL trends. Chapter 7 also discusses changes in seawater water volume within the last century.

Chapters 8 and 9 provide a fitting conclusion to the book with a discussion of a more-applied nature. For example, Chapter 8 examines the meaning of return periods and flood risks and various methods of calculating them. It then proceeds to link these risks to the climate-change debate and describe how they may vary depending on scenario. Scenarios include the effect of tidal changes and different weather patterns on coastal impacts. Chapter 8

also provides a very good introduction to responses to changes in flood risk. However, at the end of the Chapter 8, Pugh refers to the Intergovernmental Panel Climate Change (IPCC) Common Methodology as though it provides a tried and tested response strategy. Although there is a need for global cooperation in addressing the issue, this methodology has been criticized as difficult to use and having a lack of applicability for some countries.

Chapter 9 concludes the book with a discussion on the importance of sea-level changes and their influences. It examines tidal inlets and tidal flows, the impact of tides on sediment movements, the importance of tides for mangroves and salt marshes, and the zonal effect of tides on coastal ecology. The final part of this chapter places modern sea level in a geological context of sea-level change over the last 140,000 years and then ends the book on the practical note of legal definitions of tidal boundaries.

In summary, I found this book very informative and easy to read. As both a coastal scientist and a university teacher, I found its style excellent. I am sure this book will have strong appeal as a text for a number of undergraduate disciplinary programs. It will also appeal to the general public and could be particularly useful to coastal planners and engineers. ☑

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# Mass Balance of the Cryosphere

## Observations and Modelling of Contemporary and Future Changes

Edited by Jonathan L. Bamber  
and Antony J. Payne  
Cambridge University Press  
2004, 662 pages  
Hardcover: ISBN 0521808952, \$140 US

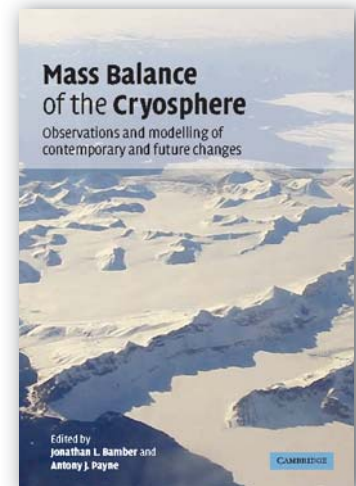
REVIEWED BY ROSS POWELL

The recent monograph edited by Jonathan Bamber and Tony Payne is an excellent resource for those researchers wishing to learn about the status of the modern cryosphere and its influence on global climate and ice-ocean interactions. The editors should be credited with assembling a fine team of experts to make the assessments, which are presented in greater detail than those in Intergovernmental Panel on Climate Change (IPCC) reports. Those chapters involving the discussion of ice-ocean interactions are perhaps the most appealing to oceanographers, and therefore, are the focus of this review.

Chapter 1 (Bamber and Payne) sets the scene for the reader placing the relevance of the cryosphere in Earth's system and also evaluating it in a temporal and spatial perspective. After this introduction, the text is divided into five parts, each part representing a different general theme. If the reader is unfamiliar with the techniques used by glaciologists for these studies, then Part I—Observational Techniques and Methods will be helpful. This part includes Chapters 2, 3 and 4,

which provide brief but competent overviews for how data are collected in areas of land-based ice (2—Hagen and Reeh) and sea ice (3—Wadhams). Useful assessments are also presented in these two chapters on pressing problems in data sets and in the appropriate algorithms used to represent natural processes in models. Chapter 4 (Bamber and Kwok) presents techniques used in remote sensing, including a review of the types of data sets available and techniques used in analyses. Discussions of data quality and coverage are helpful, although some advances have been made since the completion of this text.

Part 2—Modelling Techniques and Methods, includes three assessments, each warranting a separate chapter. The first chapter (5—Greuell and Genthon) in this section discusses modeling the mass balance of land-ice, describes how the surface energy balance is assessed and determined, describes how mass balance is modeled, and provides an assessment of the suitability of global climate models and their integration into cryospheric mass-balance studies. The discussion of modeling land-ice dynamics (6—van der Veen and Payne) starts with basic principles of ice flow, glacier dynamics and the parameters to consider in modeling. It next discusses the different approaches taken in modeling glacier dynamics and defines the critical parameters needed for the models. Importantly,



it also includes an unbiased assessment of the rigor to which the models approach reality. An extensive discussion is included on modeling the dynamic response of sea ice (7—Hibler) in the last chapter in the section. Background material about the of mechanical and physical behavior of sea ice provides the basis on which to, first, model sea ice drift and deformation; second, discuss sea ice mechanics and sea ice thermodynamics; and third, discuss the theories of ice thickness distribution. Chapter 7 ends with a thorough evaluation of the interplay between dynamic and thermodynamic models through simulations, model inter-comparisons and constraints provided by real data.

The last chapter of Part 2 provides a segue into Part 3—The Mass Balance of Sea Ice. Part 3 is divided into two chapters: one on observations (8—Laxon, Walsh, Wadhams, Johannessen and Miles) and the other on modeling (9—Flato). This part is perhaps the weakest in the compilation. The observational chapter presents a pertinent synthesis of recent changes in sea ice. Although its total emphasis on the Arctic is appropri-

ate due to current circumstances in the region, the lack of data on the Antarctic region is disappointing. As sea-ice modeling has been previously covered in Part 2 (Chapter 7), emphasis in Part 3 is instead placed on predictions and data assimilation into models.

Part 4—The Mass Balance of Ice Sheets, deals with assessments of the current mass balance of the world's major ice sheets through both observations and modeling. Chapters on observational mass balance in Greenland (10—Thomas) and Antarctica (12—Bentley) present relatively current and stimulating syntheses of data used to describe the current status of the world's largest ice masses. Problems that cannot be tackled because of lack of or poorly constrained data are clearly delineated, and future research paths are suggested. Some mention is made of the consequences on eustasy, but a thorough assessment is not presented in these chapters. An overview of consequences of the Antarctic ice sheets on sea level is provided in Chapter 13 (Huybrechts) where he discusses models that can be used to help predict

possible future behavior of the Antarctic ice sheets. Similar, but less explicit, evaluations are presented for models of the Greenland Ice Sheet (11—van de Wal). Each modeling chapter evaluates model reliability relative to reconstructions of Pleistocene ice sheet histories and the geological data constraining them, as well as the degree of fit of the models to known modern conditions.

The mass balance of smaller ice caps and glaciers is dealt with in Part 5. It seems that the background review and monitoring strategies of such systems discussed in Chapter 15 (Haerberli) would more logically be the opening chapter of this section. Instead, Chapter 14 (Dowdeswell and Hagen) opens with an assessment of the observational mass balance of Arctic ice caps and glaciers. However, it primarily focuses on data from the Svalbard archipelago in an attempt to highlight the inherent problems in trying to generalize average net contributions of glacier melt to sea-level rise. The latter technique is used to its fullest extent in Chapter 16 (Dyurgerov and Meier) where annual mass balance re-

cords from a global distribution of up to 90 glaciers (most located in the Northern Hemisphere) are used to assess net global balance and net contribution of these glaciers to 20<sup>th</sup> century and modern sea-level rise.

The last chapter (17—Payne and Bamber) provides a summary, a synthesis, and an outlook for the future. It includes reviews of the mass balance of global sea ice, the Greenland and Antarctic ice sheets, Arctic ice masses, and global averages of smaller ice caps and glaciers. Brief reviews are presented of current uncertainties in both data and models. The book concludes by providing a guide to future research needs.

In summary, this volume presents a current scholarly assessment of the status and likely future changes in mass balance of the world's major ice masses. It provides sufficient background on techniques and model assumptions, and honest assessments of strengths of current data bases and model reliability. These techniques and assessments are described in such a way that any novice can gain a solid understanding of the reliability of predicted future changes in the cryosphere and its consequences. Oceanographers, especially those who study or model ice-ocean interactions, sea-level rise, or global circulation, would find this a useful reference text for their bookshelves, although at 85 pounds sterling (\$140.00 US), some may urge its purchase by their library. ☒

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## *Books Received for Review*

### **Glaciers**

by Michael Hambrey and Jürg Alean, Cambridge University Press, 2004, 394 pages

### **Global Warming: The Complete Briefing**

by John T. Houghton, Cambridge University Press, 2004, 382 pages

### **Physical Oceanography of Frontal Zones in the Subarctic Seas**

by A.G. Kostianoy, J.C.J. Nihoul, and V.B. Rodionov, Elsevier Oceanography Series, 2004, 316 pages