Preface

Nature is a mutable cloud, which is always and never the same.

Ralph Waldo Emerson, History

Preface to the Second Edition

Since *Random Fields* was first published by The MIT Press in 1983, the reality of complex random variation, and the need to quantify and manage risks in complex systems, has been ever more widely recognized, and fast-growing computing power and database sizes have provided further motivation and empirical support for high-level probabilistic modeling. The main methods and concepts introduced in the first edition, related to the variance function and the scale of fluctuation, and the role of local averages in robust estimation of level-crossing and extreme-value statistics of random fields, have been applied in many areas of science and engineering.

In this revised and expanded edition, the order of presentation of some topics has been changed, as has the manner of exposition, so as to achieve greater clarity and coherence. A much clearer distinction is made between single-scale and multi-scale random fields, facilitated by the use of the scale spectrum. The coverage on statistical estimation of correlation parameters of single-scale random processes has been left out of the 2nd edition. New material is added, in particular on a class of quantum-physics-based probability distributions, described in Section 2.8; these all have a simple analytical form and tractable statistical properties, and promise to be very useful in a variety of applications of random field theory in physics, chemistry and biology.

The book is well suited for use in graduate-level teaching about random media and random fields, and in professional short courses on advanced methods of risk and reliability analysis. The theory's relevance to diverse academic curricula is reflected in my affiliations, at Princeton University, with the Princeton Environmental Institute (PEI), the Bendheim Center for Finance, the Institute for the Science and Technology of Materials, and the Program in Robotics and Intelligent Systems.

The universities where I did the research and teaching leading to this book (and its new edition), MIT, Princeton, and, during sabbatical leaves, Harvard and Stanford, provided inspiring and stimulating environments, and I am indebted to many colleagues and former students. I gratefully acknowledge, in particular, (the late) C. Allin Cornell, Stephen Crandall, Jose Roesset, Daniele Veneziano, Anne Kiremidjian, John Reed, George Gazetas, Mary-Ellen Hynes, Dario Gasparini, Gordon Fenton, Jeen-Shang Lin, Ronald Harichandran, Ernesto Heredia, Henri-Pierre Boissières, Waldemar Hachich, Paul Lai, Ross Corotis, Binod Bhartia, Ricardo Palma, Mark Dobossy, Mircea Grigoriu, Ignacio Rodriguez-Iturbe, Semih Yücemen, Aysen Akkaya, Ove Ditlevsen, Alfredo Ang, Masanobu Shinozuka, George Deodatis, Elizabeth Paté-Cornell, Gregory Baecher, Yin Lu (Julie) Young, Minoru Matsuo, Robert Stark, James Rice, Robert Verhaeghe, and (the late) Emilio Rosenblueth. I am much indebted as well to Hongjun Li, my editor at World Scientific Publishing Company, who patiently and expertly assisted in making this 2nd edition of *Random Fields* a reality.

Princeton, New Jersey

Preface to the First Edition

Random variation is a fact of life that provides substance to a wide range of problems in the sciences, engineering, and economics. In diverse disciplines there is a growing need to quantify aspects of the behavior of complex phenomena that can be modeled as random fields, or distributed disordered systems. This book is dedicated to developing a synthesis of methods to describe and analyze and, where appropriate, predict and control random fields.

Chapters 2 and 3 serve primarily as a review of classical theory of multi-dimensional random processes. Chapter 2 introduces elementary probability concepts and methods in a random field context, while Chapter 3 gives a concise account of second-order analysis of homogeneous random fields, in the space-time domain as well as in the wave number-frequency domain.

Chapter 4 presents a synthesis of results (many new) on level excursions and extremes of Gaussian and related random fields. Spectral moments and associated measures of degree of disorder are introduced and interpreted for different types of stochastic variation.

The main new developments are based on a proposal to treat the correlation structure of one-dimensional random processes in terms of the variance function and the scale of fluctuation. This treatment extends elegantly to multi-dimensional situations and opens the way to considerable expansion of present capabilities to deal in practical and relatively simple ways with problems involving one- and two-dimensional random variation (Chapters 5 and 6, respectively) and general n-dimensional homogeneous fields (Chapter 7). Chapter 8 proposes new methodology in the areas of estimation and prediction, and provides an application-oriented review of new results.

Much of the material is based on my recent research at the Massachusetts Institute of Technology (MIT), and could have been submitted for publication in a series of separate articles to diverse journals. In the process, however, precious bonds between related concepts and approaches would have been broken, and the opportunity offered by the monograph format to stress methodological unity would have been lost.

The book is well suited for use in teaching or self-study of the fundamentals of random fields. While new results are introduced at an appropriate level of mathematical rigor, there is no mathematics requirement beyond basic college level calculus, and every effort has been made to consolidate and simplify theory so as to render it suitable for practical application. The later chapters are substantially self-contained and can be read at different levels. Within the various chapters, each section is written as a unit with respect to the numbering of equations.

The research leading to this book has been carried out, with fluctuating intensity, over the past decade, with a concentration of effort during 1979 and 1980. It follows a course charted by Norbert Wiener and was perhaps touched by his spirit, still alive at MIT. The Institute provided a stimulating environment for the research, and I am indebted to many colleagues and former students. I acknowledge with deep gratitude the support and encouragement of my mentors in the art of applied probability, Robert M. Stark of the University of Delaware, C. Allin Cornell of Stanford University, and Stephen H. Crandall of MIT. I am very grateful to Elizabeth Augustine who patiently and expertly typed the many drafts of this book. Lieven Vanmarcke and Mark Willems assisted with numerical calculations for several tables and figures. Last but foremost, my appreciation goes to my wife and children for their constant support in countless ways.

Cambridge, Massachusetts