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978-0-521-69319-6 - Ecological Climatology: Concepts and Applications, Second Edition
Gordon B. Bonan
Frontmatter
More information

Ecological Climatology

Ecological Climatology introduces an interdisciplinary framework to understand the interaction between terrestrial ecosystems and climate change. The book reviews basic meteorological, hydrological, and ecological concepts to examine the physical, chemical, and biological processes by which terrestrial ecosystems affect and are affected by climate, and is written for advanced undergraduate and graduate students studying ecology, environmental science, atmospheric science, and geography.

The central argument is that terrestrial ecosystems, through their cycling of energy, water, chemical elements, and trace gases, become important determinants of climate. This coupling between climate and vegetation is explored at spatial scales from plant cells to global vegetation geography and at timescales of near instantaneous to millennia. The book also considers how human alterations to land become important for climate change.

This restructured edition, with updated science and references, chapter summaries and review questions, and over 400 illustrations, including many in color, serves as an essential student guide.

GORDON BONAN is a senior scientist at the National Center for Atmospheric Research, Colorado. His research interests include the ecological and hydrological processes by which land affects climate and how natural and human changes in vegetation alter climate.

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Concepts and Applications

Second Edition

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* The National Center for Atmospheric Research is sponsored by the National Science Foundation

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CAMBRIDGE UNIVERSITY PRESS
Cambridge, New York, Melbourne, Madrid, Cape Town, Singapore, São Paulo, Delhi

Cambridge University Press
The Edinburgh Building, Cambridge CB2 8RU, UK

Published in the United States of America by Cambridge University Press, New York

www.cambridge.org
Information on this title: www.cambridge.org/9780521872218

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First published 2002
Second edition 2008

Printed in the United Kingdom at the University Press, Cambridge

A catalog record for this publication is available from the British Library

ISBN 978-0-521-87221-8 hardback
ISBN 978-0-521-69319-6 paperback

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To Amie, for a life together.
To Alice, David, and Thomas, for all they have done for me.
To Lucy, who always chooses the sunny spot.

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Contents

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Frontmatter
More information

Preface

This second edition reflects a marked change from the first edition. Both share the same basic goal – to describe how terrestrial vegetation affects weather and climate. The first edition embodied three overarching principles: enduring relevance; a desire not to write a modeling textbook; and application of scientific principles to improve the quality of our environment through landscape design and urban planning. Joseph Kittredge's book entitled *Forest Influences*, published in 1948, is an example of enduring relevance. The studies he presented and the units of measurement are dated, but the concepts of how forests affect the environment are as relevant today as they were six decades ago. Mathematical models and the numerical methods to represent physical, chemical, and biological processes can quickly become dated, and in the first edition I chose to include a limited number of mathematical equations only to illustrate basic concepts. Many of the principles of ecological climatology are applicable to the built environment. Changing land use, like global climate change, is a grand unplanned experiment with unknown social and environmental consequences. Unlike global change, land use occurs locally in our communities. It gives substance to environmental issues at spatial and temporal scales to which people can see and respond; we see these changes happen in our communities, often over a period of a few years.

This second edition strays somewhat from these guiding values. It contains many more mathematical equations, but only to illustrate concepts and not with the intent of describing the state-of-the-art in model development. The book heavily references models, their scientific application, and simulation experiments to understand land–atmosphere interactions. It is still not a modeling textbook, and I hope that the lessons learned from model applications will prove to be of enduring relevance. Landscape design and the urban environment continue as recurring themes, but with a more focused discussion to maintain brevity.

The second edition contains updated science and references, but is also a complete revision and reorganization to make the material more accessible to students. The organization of the material is greatly improved. Many of the chapters in the first edition contained multiple topics. Many topical subjects were spread across several chapters. The second edition rearranges the material into coherent, topical chapters. Many of the chapters in the first edition were too long; most chapters in this second edition are considerably reduced in scope. A brief chapter summary is provided to allow readers to gain a quick overview of the book and an understanding of how the various chapters relate to one other. References are included at the end of each chapter to provide a concise list of literature relevant for that chapter and to make the literature base accessible for students as they explore particular topics in more detail. Each chapter has several review questions to reinforce key concepts.

The book is divided into an introductory chapter, which describes the general scope of the book, and 29 science chapters arranged in seven sections on: the Earth system; global physical climatology; soil processes; hydrometeorology; biometeorology; terrestrial plant ecology; and terrestrial forcings and feedbacks. New material not included or greatly expanded upon from the first edition includes: a discussion of Earth as a system, its components, and the cycling of energy, water, and carbon among components; turbulent fluxes and similarity theory; examples of surface energy fluxes measured over different vegetation types and climate zones; boundary layer meteorology and the influence of soil water on the boundary layer; examples of watershed studies; biometeorology including the study of plant canopies; a review of the development of land surface process models for use with atmospheric models; and a discussion of terrestrial influences (snow, soil water, leaf phenology) on seasonal-to-interannual climate variability. Chapters on agricultural impacts on weather and climate, coupled climate–vegetation dynamics, and biogeochemical feedbacks are updated to include new scientific advances. It is gratifying to see the extent to which the science

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has expanded since the first edition was published in 2002. This is particularly evident in the depth of material presented in the chapter on land surface models, the lengthened discussion of land use as a climate forcing, and completely new material on carbon cycle–climate models.

I am indebted to colleagues at the National Center for Atmospheric Research for supporting my efforts to write this second edition, in particular Sam Levis and Keith Oleson, whose long-standing commitment to the development and maintenance of community models, both since 1999, allowed me to write this book. David Lawrence, too, assumed a leading role in community model development, allowing me to focus my efforts on writing.

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