

Third Edition

GEOSYSTEMS

An Introduction to Physical Geography



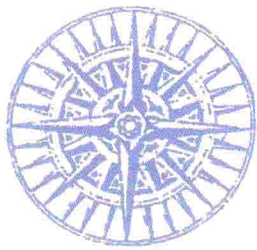
Robert W. Christopherson



Geosystems

An Introduction to Physical Geography

THIRD EDITION



Robert W. Christopherson

American River College



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***To all the students and teachers of Earth, our home
planet, and its sustainable future.
And to our Dad, who gave us the world.***

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Back Cover Photo: *Full Earth photo by Apollo 17 astronauts, December 1972, from NASA.*

Frontispiece: *Clinton Valley, Milford Track, near Fjordland National Park, South Island, New Zealand (45° S 168° E). The mark of the glaciers on this landscape is evident in the U-shaped valley and the small tarn (lake). This scene is inland from the cover photo on our second edition. Photo by Mark A. Johnson/Stock Market.*



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Preface

Earth is a place of great physical and cultural diversity, yet people generally know little of it. An informed citizenry requires meaningful education about our life-sustaining environment, and that is the purpose of this book.

The third edition of *Geosystems* builds on the qualities that made the first two editions such a success throughout the United States and Canada. Students and teachers alike have expressed appreciation for the systems organization, content breadth, readability, scientific accuracy, clarity of the glossary, functional beauty of the photographs, art, and cartography, and our up-to-date coverage. The third edition improves on these established qualities, respectfully presenting physical geography as the important Earth science that it is.

We now live on a planet served by the Internet and World Wide Web, a resource that weaves threads of information from around the globe into a vast fabric. The fact that we now have Internet access into almost all the compartments aboard Spaceship Earth is clearly evident in *Geosystems*. Such ready availability of worldwide information allowed your author to illustrate content with a fascinating array of up-to-date examples and to further verify accuracy.

For instance, to better acquaint you with what it is like to live and work in the harsh climate at the South Pole, Chapter 10 presents an account from people stationed there, as carried on the Internet (<http://205.174.118.254/nspt/home.htm>). This third edition reflects the richness of the Internet as a resource and useful supplement to the scientific literature. And to reinforce our connection—student-teacher-author—we are linked through our own *Geosystems Home Page* at <http://www.prenhall.com/geosystem>).

***Geosystems* Communicates the Science of Physical Geography**

The goal of physical geography is to explain the spatial dimension of Earth's dynamic systems—its energy, air, water, weather, climate, tectonics, landforms, rocks, soils, plants, ecosystems, and biomes. Understanding human-Earth relations is part of the challenge of physical geography—to create a holistic (or complete) view of the planet and its inhabitants. A goal of *Geosystems* is to serve this need by demonstrating that physical geography is a critical Earth systems science.

Geosystems is well suited to your study of physical geography, whether you are a geography major or are taking this class as a science elective. Clear graphics and explanations are designed to help you understand

essential concepts of how Earth works. This attention to your needs as a student makes *Geosystems* an accessible science text.

In Chapter 2, two brief essays introduce you to scientific thinking and processes—a Focus Study explains the scientific method and a News Report describes “The Nature of Order is Chaos.” Throughout the text, the latest scientific discoveries and techniques are employed as we explore physical geography. Take a moment to sample the pages of the text and you will find an excitement in the presentation of our remarkable planet.

Geosystems analyzes the worldwide impact of an event, synthesizing many physical factors into a complete picture. A good example is the 1991 eruption of Mount Pinatubo in the Philippines. The global implications of this major event (one of the largest eruptions this century) are woven throughout the book (Chapters 1, 3, 4, 5, 10, 12, and 21), not just in the section on volcanoes. Our update on global climate change and its related potential effects is part of the fabric in six chapters. Information from current research includes the 1990, 1992, and 1995 reports from the Intergovernmental Panel on Climate Change (IPCC). These content threads tie together the many interesting and diverse topics crucial to a thorough understanding of physical geography.

Systems Organization Makes *Geosystems* Flow

Each section of this book is organized around the flow of energy, materials, and information. *Geosystems* presents subjects in the same sequence in which they occur in nature. In this way you and your teacher logically progress through topics which unfold according to the flow of individual systems, or in accord with time and the flow of events. For flexibility, *Geosystems* is structured in four parts, each containing chapters that link content in logical groupings.

Chapter 1 presents the essentials of physical geography as a foundation, including an overview of geography, systems analysis, latitude, longitude, time, the science of mapmaking (cartography), remote sensing, and geographic information systems (GIS). With these essentials learned, each of the four parts can then be covered in their present order or in any sequence preferred by the teacher.

Part One, Chapters 2 through 6, shows the systems organization of the text, beginning with solar energy flowing across space to Earth's atmosphere, varying in intensity by latitude and season as the solar angle and

daylength change. Energy is traced through the atmosphere to Earth's surface, where patterns of temperature and air pressure are generated. Part 1 concludes with general and local atmospheric and oceanic circulations. Human-Earth themes are woven through the presentation in these chapters: the new UV Index, 1995 Nobel Chemistry Prize for ozone research, solar and wind energy resources, air pollution, acid deposition, and heat-index deaths in Chicago in 1995. Ocean currents take on new meaning with a map that shows the journey of a message in a bottle and the odyssey of toys spilled from a cargo ship.

Part Two presents water, weather, violent storms, water resources, climate, and climate change, in a flowing sequence from Chapters 7 to 10. The section on water balance explains water resources from varied perspectives, from a house plant or front lawn to vast regional water projects.

In *Part Three*, physical geography is linked to other Earth sciences, an influence seen in Chapters 11 through 17 where we discuss the physical planet and related processes that affect the crust. Earth's surface is a place of enormous struggle between tectonic processes that build, warp, and fault the landscape and those that wear it down through the action of rivers, wind, waves, and ice. Dramatic recent earthquakes in Northridge, California, and Kobe, Japan, are highlighted in Chapter 12.

Finally, *Part Four* integrates the content of the first three parts in biogeography: including soils, ecosystems, and Earth's major terrestrial biomes (Chapters 18 through 20). Critical topics are covered: soil fertility and soil loss, biodiversity, fire ecology, the Great Lakes ecosystem, and desertification, among others.

The text culminates with Chapter 21, "Earth, Humans, and the New Millennium," a unique capstone chapter that summarizes physical geography as an important discipline to help us understand Earth's present status and possible future. This chapter is sure to stimulate further thought and discussion, dealing as it does with the most profound issue of our time, *Earth's stewardship*. An important new study is summarized that examines the costs and benefits of the Clean Air Act. The study reports a 20 to 1 net benefit ratio from regulations directed at cleaning the air. The five agreements reached at the historic 1992 Earth Summit—the United Nations Conference on Environment and Development, held in Rio de Janeiro—are detailed in a focus study.

Geosystems is a Text That Teaches

Geosystems is written to assist you in the learning process. Three heading levels are used throughout the text and precise topic sentences initiate each paragraph to help you outline and review material. **Boldface** words are defined where they first appear in the text.

They also are collected in the Glossary and are identified alphabetically and by chapter number. *Italics* are used to emphasize other words and concepts. Also, every figure now has a title that summarizes the caption.

An important new feature in this third edition is the 5 or 6 *Key Learning Concepts* that open each chapter, stating what you should be able to do upon completing the chapter. These objectives are keyed to the main headings in the chapter. At each chapter's end is a unique *Summary and Review* section that corresponds to the *Key Learning Concepts*. Grouped under each learning concept is a narrative review that redefines the boldfaced terms, a key terms list, and specific review questions for that concept. You can conveniently review each concept, test your understanding with review questions, and check key terms in the glossary, then return to the chapter and the next learning concept. In this way, the chapter content is woven together with specific *concept threads*.

Critical thinking is activated by the book's structure and presentation. The key learning concepts help you determine what you want to learn, the text helps you develop more questions and answers, and the summary and review helps you assess what you have learned and what more you might want to know about the subject. The text and our home page give you many facets of a subject with which to develop your own point of view. The *Geosystems* home page adds important dimension to interactivity and critical thinking.

Features of this Fully Revised Third Edition

Every chapter of the third edition is thoroughly revised, updated, and expanded, with new or improved maps, photographs, art, and tables. There is expanded coverage of global change, climate, the Great Lakes, weather models, and Canada. (Instructors: the *Instructor's Resource Manual* details these changes by chapter.) The many new figures in this edition are fully integrated within the text discussions. Here are a few of the features of the third edition:

- Our widely praised cartography program is updated to reflect the rapid pace of change in political boundaries and physical systems. Of all the maps in the text, 40% are new to this edition. Locator maps accompany most remote sensing images and photographs. Also, numerous topographic maps, many new to this edition, are used to illustrate key features of the landscape.
- Photographs from every continent are included in our 375 photos; 60% are new to this edition. Many photos are integrated with art so you can compare the concept shown in the art with a representative scene from the real world. For example: the four

seasons on land and in orbit (Figure 2-21 and 2-22), limestone landscapes and caverns (Figure 13-18), Earth's major deserts (Figure 15-14), glacial features (Figure 17-9 and 17-13), and the Great Lakes shorelines (Focus Study 19-1).

- New, expanded coverage of the Great Lakes: lake-effect snow (Chapter 8), formation of the Great Lakes (Chapter 17), and a new focus study on the lakes and their ecosystems (Chapter 20).
- Continued coverage of Canadian physical geography includes text, figures, and maps of periglacial landscapes (a new focus study in Chapter 17) and Canadian soils (a new Appendix C). Canadian data on a variety of subjects are portrayed on 25 different maps in combination with the United States—physical geography does not stop at the United States–Canadian border!



Twenty-one “Focus Study” essays, some completely revised and several new to this edition, provide additional explanation of key topics as diverse as the stratospheric ozone predicament, wind power, forecasting the near-record 1995 hurricane season, the El Niño phenomenon, an environmental approach to shoreline planning, the Mount St. Helens eruption, the status of the Colorado River, and the loss of biodiversity.



Seventy “News Reports” relate topics of special interest. For example: careers in GIS, jet streams and airline flight times, how one culture harvests fog, the new UV Index, using Earthshine to study global energy budgets, the disappearing Nile Delta, humans eat clay, how sea turtles read Earth's magnetic field, and drilling for oil in the rain forest.



The *Geosystems Home Page* provides on-line resources for each chapter on the World Wide Web. You will find review exercises, specific updates for items in the chapter, suggested readings, and links to interesting related pathways on the Internet. A click on the Table of Contents link and selection of a chapter launches you into this new dimension of physical geography.

- The text and all figures show both metric and English measurement. This is done to help us through this transition period as we change from English units to metric. A complete set of measurement conversions is presented inside the back cover.

The Geosystems Learning/Teaching Package

The third edition provides a *complete* physical geography program for you and your teacher.

For You the Student:

- **Student Workbook** (ISBN: 0-13-505405-2), by Robert Christopherson. The workbook includes additional learning objectives, a complete chapter outline, critical thinking exercises, problems and short essay work using actual figures from the text, and a self-test with answer key in the back.



Internet Support by Duane Griffin and James E. Burt, University of Wisconsin-Madison, and Robert Christopherson. Our **Geosystems Home Page** (<http://www.prenhall.com/geosystm>) gives you on-line review exercises, opportunities to delve deeper into subjects out on the Net, follow-up answers to specific items in the text (for example, the forecast outcome of the 1996 and 1997 Atlantic hurricane seasons), and links to a wealth of interesting sites that relate to each chapter.



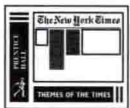
Life on the Internet: Geosciences by Andrew T. Stull and Duane Griffin is a student's guide to the Internet and World Wide Web specific to geography. It is available *free* as a shrink-wrap with the text.

For Your Teacher: *Geosystems* is designed to give you flexibility in presenting your course. The text is comprehensive in that it is true to each subject area from which it draws content. This diversity is a strength of physical geography, yet it makes it difficult to cover an entire book in a school term. You should feel free to customize use of the text based on your specialty or emphasis. The systems organization within each chapter, four-part structure of chapters, focus study and news report features, all will assist you in sampling some chapters while covering others to greater depth. The following materials are available to assist you—have a great class!

- **Instructor's Resource Manual** (ISBN: 0-13-505348-X), by Robert Christopherson and Cecilia Huddleson of Foothill College. The *Instructors Resource Manual*, intended as a resource for both new and experienced teachers, includes a variety of lecture outlines, additional source materials, teaching tips, advice on how to integrate visual supplements, and various other ideas for the classroom.

- **Geosystems Test Bank** (ISBN: 0-13-505330-7), by Robert Christopherson and Marcus Gillespie of Northwest Missouri State University. This collaboration has produced the most extensive test item file available in physical geography. (Mac Test Manager 013-505389-7 and IBM/DOS Test Manager 013-505371-4 are available).
- **Overhead Transparencies** (ISBN: 0-13-505355-2) include 105 illustrations from the text, all enlarged for excellent classroom visibility. And, *Slide Set* (ISBN: 0-13-505363-3) includes illustrations and some photographs from the text.
- **Applied Physical Geography-Geosystems in the Laboratory**, 2nd edition (ISBN: 0-13-505405-2), by Robert Christopherson and Gail Hobbs of Pierce College. This new edition is greatly expanded and improved over the original. Twenty-two lab exercises, divided into logical steps, allow flexibility in presentation of labs. A solutions manual is available.
- **Prentice Hall GEODISC** © (ISBN: 0-13-304163-8) is available to adopters to supplement the text with over 900 pictures and illustrations, 12 minutes of animations, and 50 minutes of motion video segments on an interactive laser disk with bar codes.

ABCNEWS Prentice Hall-ABC News Video Library is a collection of broadcast segments that highlight many related current events.



Prentice Hall-New York Times **Themes of the Times** supplements, *Geography* and *The Changing Earth*, reprint significant recent articles on related topics.

Acknowledgments

As in past editions, I must first recognize my family, for they have endured my absence while I worked on *Geosystems*, yet they never wavered in their loving support—my Mom and Dad, my sister Lynne, my brothers Randy and Marty, and our children Keri, Matt, René, and Steve. And now the next generation—Chavon, Bryce, and our newest, Payton. When I look into our grandchildren's faces it tells me why we need to work toward a sustainable future; one for the children.

My thanks go to the many authors and scientists who published research, articles and books, and shared with me over the Internet, e-mail, FAX, and phone. And I give special gratitude to all the students over these past 27 years at American River College for defining the importance of Earth's future, for their questions, and their enthusiasm. *To all students and teachers this text is dedicated.*

I owe many thanks to my colleagues who variously served as reviewers on one or more editions, who participated in our focus groups, or who offered helpful

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Physical geography teaches us a holistic view of the intricate supporting web that is Earth's environment and our place in it. Dramatic changes that demand our understanding are occurring in many human-Earth relations as we approach the new millennium. All things considered, this is an important time for you to be enrolled in a physical geography course! The best to you in your studies—and *carpe diem*!

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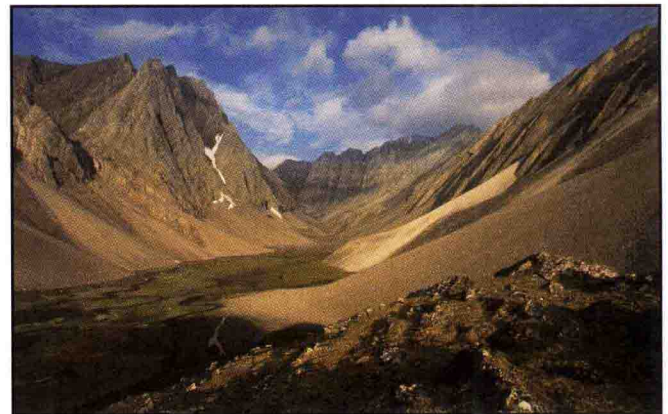
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