Earth System Science From Biogeochemical Cycles to Global Change

Edited by:

Michael C. Jacobson, Robert J. Charlson, Henning Rodhe and Gordon H. Orians

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Reviewer:

Ted Lilley

Research School of Earth Sciences

Australian National University, Canberra

This book is the second edition of one published in 1992 under the title Global Biogeochemical Cycles, and edited by Samuel S. Butcher, Robert J. Charlson, Gordon H. Orians and Gordon V. Wolfe. It is stated that 5000 copies of the first edition were distributed.

The second edition contains all the material in the first, in an updated form, and adds a fourth part. The co-editorship has changed accordingly. The title thus records some history. In the years since 1992, the idea of a whole-Earth system has become a most satisfying concept, and global change is one of the present most-studied subjects.

The nineteen chapters have been contributed by a total of 28 authors. Their range is international, with some 13 from the University of Washington, Seattle. The co-editors are from the University of Washington (three) and the University of Stockholm (one), and it is clear that the book has developed from courses given at these two institutions, in particular. Possibly there has been beneficial wider feedback after the first edition. The material shows the benefits of usage in, for example, problems set at the ends of chapters (with answers at the back of the book). The book has handy lists of physical quantities and basic physical data inside the covers (in SI units, increasingly the accepted standard now). The International Geophysics Series of Academic Press is in fact edited by James R. Holton, of the University of Washington, Seattle.

This is a remarkable book, ultra topical in today's Earth science, and a treasure-house of information. So much is here, in fact, that it will be mainly a reference book to dip into, rather than to read straight through.

In four parts, it starts with basic concepts for Earth System Science. It makes the point that the Earth is effectively a closed system from the point of view of matter, and that the most important characteristic from a human perspective is that it has abundant life in a biosphere. The first part has foundation chapters on biogeochemical cycles, on the origin and early evolution of the Earth, on the evolution and the biosphere, on the principles of modelling biogeochemical cycles, and on the concepts of equilibrium and rate in natural systems.

Part two then has chapters on the properties of and transfers between the key reservoirs. Five reservoirs have a chapter each, these being water and the hydrosphere; the atmosphere; soils, watersheds and marine sediments; tectonic processes and erosion; and the oceans.

Part three moves to biogeochemical cycles particularly, with chapters on the carbon cycle, the nitrogen cycle, the sulphur cycle, the phosphorus cycle, and trace metals.

Part four then brings it all together (and is indeed called Integration), with chapters on the acid-base and oxidation-reduction balances of Earth, and on the couplings of biogeochemical cycles and climate. Then a chapter on ice sheets and the ice-record of climate change, and finally a chapter on human modification of the Earth system, and global change.

The book has four colour plates, included together at the centre of the book. They give a sample of the range of the book: the first is a diagram of the whole Earth as seen from say the Moon, with radiation from and to space, the atmosphere and the oceans driving sediment transport, and mantle convection driving the tectonic plates. At Earth's surface the rain causes erosion, and the rivers carry sediments to the sea. Biological processes are closely involved.

Plate 2 is of a section of the atmosphere derived from space-shuttle data, showing (for example) dust clouds from the Sahara carried over the Atlantic Ocean by the trade winds. Plate 3 is a world map showing the different global soil regions. Plate 4 is an image of the sea-floor topography for the Pacific Ocean and surrounding continental areas.

A hazard of a multi-authored book of this kind is that the different chapters will be disjointed and not flow together seamlessly; they will either have gaps between them, or else overlap and repeat material. My impression is that careful editing has countered any such tendency in this case.

There is another point about a book, which is very intentionally 'integrative'. Students meeting various concepts (in physics, chemistry, biology or mathematics) for the first time in this book may pick up much basic science as they go along. However, some prior foundation is needed to fully appreciate the application of these disciplines to the Earth.

Pondering this point led me to think of the pre-twentieth century natural philosophers, faced with the world being revealed in front of them. They were armed with a developing strategy of scientific thought, and started to work through the observed phenomena with a 'divide and rule' approach. Natural phenomena were divided into the subjects of physics, chemistry, biology, etc., and within these subjects analysis continued until each subject was reduced to a fundamental level. Only thus, it was accepted, could the observed phenomena be correctly understood. The present book in a way completes a grand cycle, with these individual disciplines (conquered?) now synthesized again, and the whole Earth system, as we see it, analysed together as a unit.

A wealth of information can be found inside. How well can you explain El Nino to your neighbour? Go to the diagram on page 239. Wondered what the 'conveyor belt' model for global ocean current circulation is? Go to page 244. And, on the most important point of whether global warming is a reality, go to page 507, and find: "As much as we know about the increase in CO2, the forecast of climatic response is unclear..."

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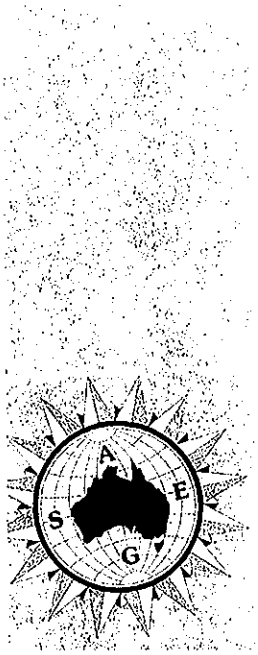

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However this book is not the place for solid-Earth geophysics information. Generally it stays clear of the long-time-scale processes of mantle convection, plate tectonics and subduction zones, and also the generation of the main geomagnetic field in Earth's core, and the significance of geomagnetic reversals. The editors would surely agree that the total Earth system includes such phenomena. It is clear they have had to draw the line somewhere, and they may very justifiably have the view that such traditional material is now found elsewhere. Their focus is generally on events of shorter time-scales, such as occur in the atmosphere and oceans.

For exploration geophysicists, used to thinking in terms of the Earth as a place of hard physical quantities (the gravity field, seismic wave-speeds etc.) I think this book brings a very mind-expanding exercise of paying attention to chemistry and biology, and recent and current geological processes. After all, the profession can not know what aspects of Earth it will be called on to measure, map and interpret in the future, and the last ten years have emphasized the importance of environmental matters.

What is Earth System Science in a nutshell? Let me quote from the final chapter: "We have learned much about the individual parts and processes of the Earth's atmospheric, oceanic, continental, physical, chemical, and biological systems. However, we have just started to understand the linkages and feedbacks that make these systems function as a single entity. ...we do know that the global system is changing as a result of known processes... ...and that current changes are large compared to natural ones in the past."

A phone call to a Canberra bookshop brought the advice that this book is published in paper-back only, at price $147 (including GST). I understand this price is on the expensive side both generally, and for Academic Press in particular. However let me again say that there is a lot of information contained in the book's 527 pages, and if it is what you want it will be a very rewarding investment.