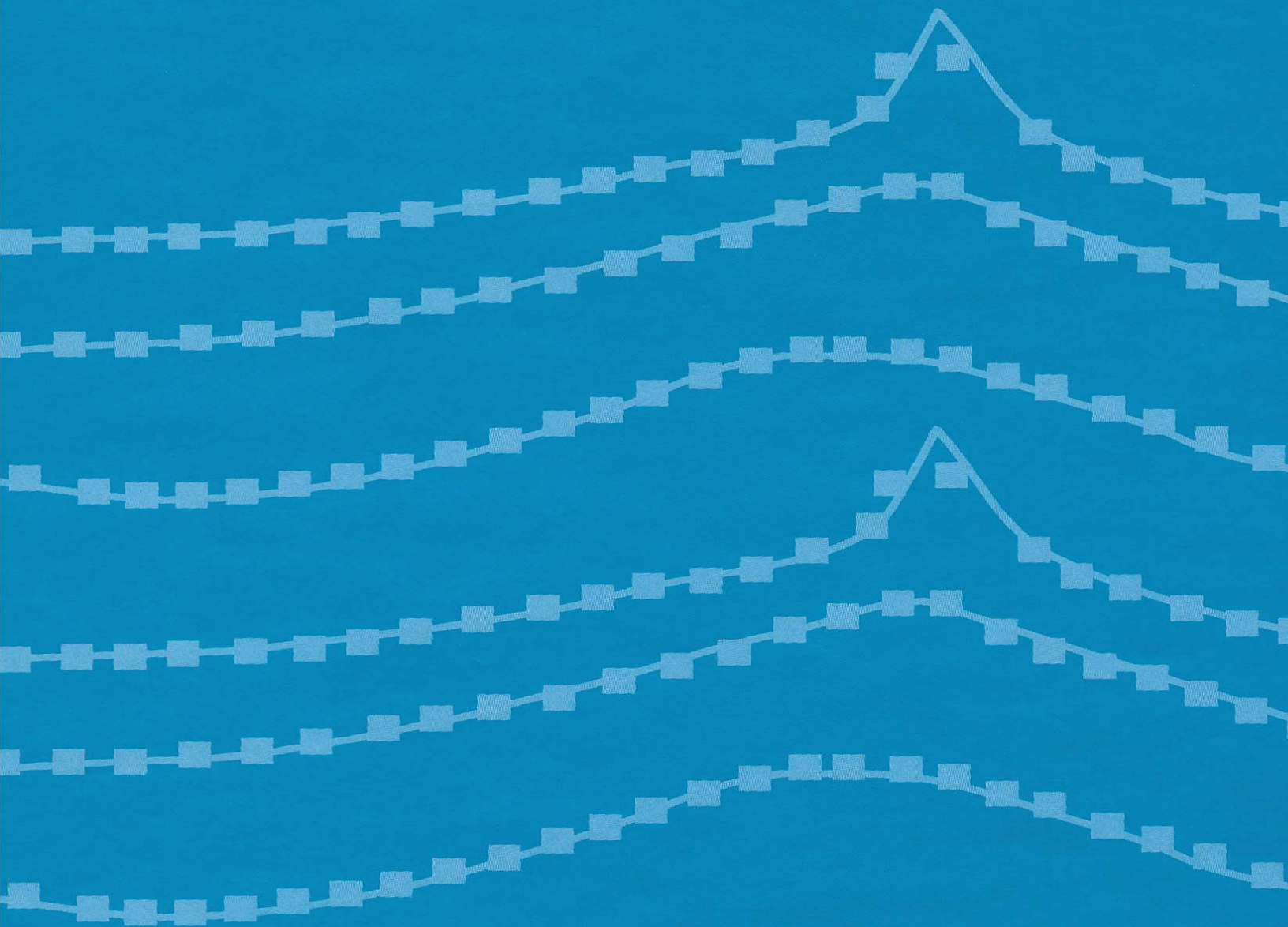


Light and Water

Radiative Transfer in Natural Waters



Curtis D. Mobley

Preface to the CD Edition

At the time *Light and Water* was published in 1994 I simply wanted to get it off of my desk and never think about it again (a common feeling among authors, I'm sure). It has been a gratifying surprise to me that so many of my colleagues have found the book useful. Also interesting is the variability in the feedback I have received from readers. Some criticize the book for giving too much mathematical detail, while others ask for more detail; some have told me that Chapter 4 is of no interest to anyone and should have been omitted, and others have told me that Chapter 4 is the best in the book; and so on *ad infinitum*.

The original hardcover printing sold out in 2002 and the book went out of print. However, frequent email enquires to me showed that there was still demand for the book. Academic Press kindly returned the copyright to me, and Dr. Steven Ackleson of the Environmental Optics Program of the U. S. Office of Naval Research offered to fund the conversion of the book to a CD format for wide distribution. For the CD version, I corrected the many typographical errors found in the first edition, and I added a small set of Supplementary Notes to provide a bit of extra discussion where needed. The original pagination has been retained in the CD version.

Yes, some sections of *Light and Water* are now out of date, and I certainly would love to write a new book that surveys the vast amount of knowledge gained in the 15 years since I started writing *Light and Water*. But, until I find a sponsor willing to fund me for a year of writing, we'll all have to be content with reissuing *Light and Water* on CD format. I am personally content with the thought that my imperfect efforts of so long ago remain useful.

Enjoy!

Curtis D. Mobley

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Preface

Books on radiative transfer theory and optical oceanography fall into two groups. One group contains very mathematical treatments of radiative transfer theory (such as the 1757-page treatise *Hydrologic Optics* by Preisendorfer). The other group contains books that are either descriptive (such as the classic *Marine Optics* by Jerlov) or that give only an overview of radiative transfer theory in order to set the stage for discussions of other topics (for example, Kirk's *Light and Photosynthesis in Aquatic Ecosystems*). This book fills the gap between these two groups.

This book develops radiative transfer theory in a form suitable for application to the world's oceans, estuaries, lakes, rivers, and other natural water bodies. I have structured this book so as to achieve several goals:

- To develop in detail the equations governing the propagation of visible light both across wind-blown air-water surfaces and within water bodies.
- To summarize the optical properties of natural waters in forms suitable for input into radiative transfer predictive models.
- To develop numerical methods for solution of the radiative transfer equations in settings that are realistic approximations of nature.
- To illustrate the nature of underwater light fields and their dependence on water optical properties and external environmental conditions.

My development of radiative transfer theory for natural waters is complete and precise. However, the emphasis is on physical understanding, not upon mathematical generality or rigor. The book interleaves two levels of discussion. The first level develops the basic theory and reviews the current literature on optical oceanography. This level of discussion is directed toward students who have had only introductory courses in calculus and physics, as can be assumed for any beginning graduate student of oceanography. The second level of discussion develops numerical methods for solution of the radiative transfer equations. This level requires some knowledge of ordinary differential equations and matrix algebra. I have flagged those sections that

deal with the details of numerical algorithms by two bars: **||**. Readers desiring only an overview of hydrologic optics can skip the barred sections.

Each chapter closes with problems of easy to moderate difficulty. The following sections provide sufficient material for a one-semester course in optical oceanography: Chapters 1 and 3, Sections 1 and 6 of Chapter 4, Chapters 5, 6, 10, and 11. The remainder of the book generally deals with numerical methods. These numerical methods are of general applicability and should be of use to researchers in disciplines such as atmospheric and bio-medical optics, as well as hydrologic optics. I have cited well over 300 references in order to connect the reader with the large body of literature on optical oceanography and radiative transfer theory.

Genesis

In 1980 the late Rudolph Preisendorfer began writing a condensation of his six-volume treatise *Hydrologic Optics*, which was never commercially available. At about the same time, I began working with Rudy to develop numerically efficient algorithms for the solution of radiative transfer equations in settings that mimic the complexities of natural water bodies. As we made progress in our numerical investigations, Rudy's "condensation" of his six volumes evolved into "volume seven: numerical methods." That book was perhaps one third done when he unexpectedly died in 1986. Further writing was placed on hold while I completed our other joint projects and while I served as Program Manager of the Oceanic Optics Program at the Office of Naval Research from 1989 to 1991. Not until 1992 was I able to return to full-time writing on the book.

At that time, I decided that a comprehensive text book for students of optical oceanography and limnology would be of much greater value than a mathematically oriented book restricted to numerical methods. I therefore began anew with page one. I believe that Rudy would be pleased with the final, expanded version of what he started in 1980. The present Chapters 4, 7, 8, and 9 are essentially the book as it existed at the time of his death.

I have chosen to write in the first person plural, in part because it is a relaxed style that includes the reader in the dialogue, but also to acknowledge Rudy's presence looking over my shoulder as I completed the book for both of us.

Acknowledgments

Many persons contributed immensely to this book. I received valuable reviews of draft chapters from Roman Glazman, Howard Gordon, Steven Hawes, George Kattawar, Robert Maffione, Norman McCormick, Andr Morel, Stuart Pilorz, and Dariusz Stramski. Norm McCormick's line-by-line review of the first ten chapters was exceptionally valuable. Had Richard Spinrad not lured me to the Office of Naval Research (ONR) from 1989 to 1991, the book would have been finished two years earlier. However, during my stay at ONR, I gained a broad overview of the entire field of oceanic optics, which led to a much improved book. Rick Spinrad receives my special thanks for his positive influence on my career and on the book. During my stay at the Jet Propulsion Laboratory (JPL), California Institute of Technology, from 1991 to 1993, Donald Collins and Curtiss Davis provided me with the perfect intellectual atmosphere for completing the book. Their professional and social hospitality could not be surpassed. An Tran and Michael Hamilton of JPL assisted greatly in my transition from supercomputers and FORTRAN written in capital letters to the world of UNIX workstations. Stephanie Blueford and Peter Cremo of JPL typed first drafts of several of the chapters.

I was supported financially during my early research years with Rudy Preisendorfer by the Tropical Ocean-Global Atmospheres Program, through grants to Preisendorfer. After his death, I wrote several chapters with support from the Oceanic Biology Program at ONR. The writing was kept alive via the Science Officer Research Program while I was at ONR. My stay at JPL as a National Research Council Resident Research Associate (Senior Level) was supported by the Ocean Biogeochemistry Program at NASA Headquarters. I wrote the final chapters with support from ONR's Oceanic Optics Program under grant number N0001494MP23002.

Finally, and most importantly, I could not have finished the book without the continued and unwavering moral support of my wife, Ann Kruse. She sacrificed many weekends in the mountains while I worked, and she tolerated the stresses of deadlines without complaint. I dedicate the book to her with the deepest love and appreciation.