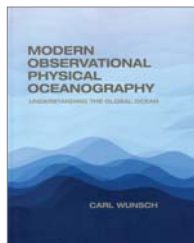


Modern Observational Physical Oceanography

Understanding the Global Ocean

Carl Wunsch

Princeton U. Press, 2015. \$99.50 (493 pp.). ISBN 978-0-691-15882-2



Oceanographer Carl Wunsch has based his career on the proposition that we can understand the physics of the global ocean's circulation and its forcing through observations. That's audacious, considering the ocean's volume is about 1.3×10^{18} cubic meters, horizontal scales of important dynamic processes range from submillimeter lengths to scales spanning the globe, and time scales for significant variations range from fractions of a second to millennia.

Observing the ocean is a challenge. Seawater's opacity to electromagnetic radiation limits remote sensing to the upper meters. Instruments are subject to corrosion and extreme pressures. And the violent storms likely to occur on the extended missions that are necessary to collect *in situ* data on global scales are sure to challenge the intestinal fortitude of most observers.

And yet, new observation methods, paired with new analytical techniques, have driven excellent progress in understanding the dynamics of ocean processes and circulation. Also driving progress is a greater appreciation, by the public and by policymakers, of the ocean's role in Earth's climate and the urgent need to understand our changing climate. For example, observations have been instrumental in quantifying the intimate connection between the ocean and atmosphere as a result of oceanic evaporation. Latent heat exchange drives evaporation of about 13 million tons of water per second; the resulting atmospheric energy flow (due to the moist atmosphere) is balanced by oceanic flows that, in effect, move freshwater around. Those coupled processes account for around one-third of the total meridional energy transport required to balance Earth's net radiative heating.

Modern Observational Physical Oceanography: Understanding the Global Ocean encapsulates a half-century of contributions by Wunsch, whose PhD adviser was the incomparable Henry Stommel. And

what an immense contribution the recently retired Wunsch has made: more than 250 papers, 5 books, and an astonishing list of master's and PhD students whose own merits are widely recognized.

His latest book breaks new ground for an oceanographic text in successfully describing what observations have taught us about the ocean as a time-varying system. It achieves that by explaining the directness with which observations and physics are connected, by placing the observations as the central element of the story, and by describing first their context and then the physics that explains the observed phenomenon. The book also stresses the importance of using observed ocean data to constrain models that predict climate change, which Wunsch views as a high priority for society.

A major strength of the book is its clear discussion of what can safely be concluded from observations. It also makes clear how the conclusions are to be defended as well as the corollary: when analysis becomes storytelling and plainly bad science (for example, the impact of aliasing). Reading this book leaves a very powerful impression of robust and serious science.

Wunsch covers global themes that span many major topics in large-scale physical oceanography. As stated in the preface, the intended audience is graduate students and working scientists, but I believe the text will benefit all observational oceanographers.

Where does this work sit in the bookcase of oceanography texts? If multidimensional books sit on the top shelf, then that's where you'll find *Modern Observational Physical Oceanography*. It combines theory—the focus of such texts as Adrian Gill's *Atmosphere–Ocean Dynamics* (Academic Press, 1982)—with a nice primer on analytical methods, which was the exclusive focus of Richard Thomson and William Emery's *Data Analysis Methods in Physical Oceanography* (3rd edition, Elsevier, 2014). The result of that combi-

nation is a product that goes beyond such texts as Lynne Talley and coauthors' excellent *Descriptive Physical Oceanography: An Introduction* (6th edition, Elsevier, 2011).

Wunsch's book also distinguishes itself from the others by placing observational data as the central character and by emphasizing the oceans' time-varying nature. And lecturers will appreciate that no additional consent is required to use the book's diverse figures and illustrations.

In several places in *Modern Observational Physical Oceanography*, I read with real pleasure about some new insight or neatly described analysis, and I enjoyed diversions such as the discussion of paleotides and the increase by 1.7 microseconds per century in a day's length mostly due to tidal friction. This widely interesting book will be of value to anyone wishing to know more about how to observe the ocean, interpret the data, and gain insights on ocean behavior and on how oceanographers reach their understanding of it.

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Nature's Third Cycle

A Story of Sunspots

Arnab Rai Choudhuri

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The cyclic magnetic activity of the Sun is among the most intriguing phenomena in the universe. It results from complex interactions in a magnetized, turbulent plasma that cover a wide range of spatial and temporal scales. Solar activity is usually associated with an 11-year variation in the sunspot number and in strong, highly energetic events—for example, coronal mass ejections and flares—that release energy equivalent to a billion 10-megaton hydrogen bombs. The resulting flux of high-energy particles interacts with Earth's magnetosphere, causing auroras and geomagnetic storms that can disrupt electrical power systems, navigation systems, satellites, and more.

In *Nature's Third Cycle: A Story of Sunspots*, solar physicist Arnab Rai Choudhuri presents the history of empirical and theoretical studies of global solar variations and discusses the influence of that activity on Earth's environment.