WEEKS, W.F. 2010. *On sea ice* (with chapter 16 contribution by W.D. Hibler, III). Fairbanks, AK, University of Alaska Press. 664pp. ISBN-10: 1-602230-79-X, ISBN-13: 978-1-602-23079-8, hardback. US$85.

On sea ice, by W.F. 'Willy' Weeks, is written by one of the longest contributing authors to the field of sea ice (he began in the fall of 1955). What makes this book unique is the wrapper of integrated hindsight at its beginning and end which includes both the historical and political motivations of polar-engaging nations. The beginning sections, including 'About the author' and the historically themed chapter 2, reveal two perspectives on the pursuit of scientific knowledge in the polar regions. The first is the study of sea ice as an international scientific discipline owing its origins to ambitious and dedicated individuals and their lifelong pursuit of knowledge to advance human understanding. This is the core perspective throughout the book, with topics of most interest to the author being traced back to the original international sources including Weyprecht, Zubov, Nansen and many others. The author additionally provides an abundance of quotations for the reader to ponder at the beginning and end of most chapters.

The second perspective is the sobering one of the constraints imposed on science by funding that is driven primarily by the political and military agendas of nations and their agencies which seek to leverage knowledge when it suits their needs while disregarding clear and obvious insight when it contradicts the agenda of the times. Weeks recounts the example of William Scoresby the younger, though it is clear from his tone that he could easily recount contemporary analogs. This insight is crucial for any young scientist wishing to understand the larger arena in which science has long had to endure. The good news is that Weeks is a positive advocate for those who adopt the first of the above perspectives, with some good advice for maneuvering through the second.

To understand the personality and intent of the author, the reader is recommended to consider the conclusion first, then appendix C (on sampling). The latter, in particular, provides a real nuts-and-bolts perspective on sea ice which few are able to experience first-hand anymore. This seemingly obscure section provides insight into basic polar research and how it is really done – the hard way – with team effort and sweat. There are hundreds of unsung heros behind every published manuscript. Behind every high-profile project there are thousands of hours of little projects and these, actually, produce the most scientific value. The author encourages the reader throughout the book to consider: 'how did they get those data?' With this insight, you read in the 'About the author' section about the career of someone who maneuvered through the military system into the civilian sector to promote the field of sea ice by tapping rich resources leveraged from timely political issues with long-term pay-offs. The introduction, and especially the historical background in chapter 2 are a must-read for those interested in this long-term perspective. An initial read of chapter 18 is warranted thereafter, as it brings the historical perspective into the modern era by addressing the scientific–statistical complexities that are developing as trends in sea ice shift downward, especially in the Arctic.

Once the reader is familiar with the superstructure provided in these chapters, the core scientific chapters provide instruction in many fundamental elements. Chapter 3 on oceanography is a skim at best, as Weeks acknowledges, but as an introductory chapter it is refreshing because it returns the reader to the fundamentals of scientific knowledge regarding a living and dynamic planet. The remaining chapters (4–17) divide into three parts: fundamentals, sea ice as a material, and select large-scale topics.

The book serves as an excellent upper-undergraduate to graduate text on the subject of sea ice for a person well versed in any of the fundamental fields of engineering, physics, mathematics or environmental studies (including oceanography, meteorology, climatology or computational physics). There is sufficient explanatory narrative within each technical section to provide not only the scientific but also the historical context which explains how the various solutions came about. I therefore recommend this book to anyone new to the field, as a foundation for grasping much of the classic literature.

The fundamentals of thermodynamics are covered in chapters 4 and 9, beginning with the basic concept of a degree-day in chapter 4 and the original simple models for computing ice growth. The chapter also covers the important concept of ice age which is often imprecisely conveyed in the literature. Essentially, Weeks tries to correct the misconception that the age of an ice floe is based on how long it has been floating. This concept contradicts the fact that different layers of the ice have existed within that same floe at different times and so every floe is dynamically evolving. The references are rather dated as they are based on sea ice with a sustainable seasonal cycle, so the reader is encouraged to refer to the newest literature (post-2005) regarding changes in ice-floe structure in response to increasing summer temperatures above the freezing point.

Chapter 9 delves deeper into the thermodynamics by examining many of the fundamental terms used in climate models to numerically evolve the growth and decay cycles of sea ice. Again, the references date mainly from the 1990s, with several additions made since, especially by large international modeling communities. This chapter is a good source for the underlying principles of inherent elements in all current thermodynamic numerical models. The explanations are clear, and well suited for most upper-level undergraduates and beyond.

Basic properties are covered in chapter 10, including the concept of sea-ice density, thermal properties and the compounded difficulties of snow cover. The bulk of this chapter focuses on structural, mechanical and electromagnetic properties, with which Weeks was involved for many years.

The fundamentals of dynamics are well summarized in chapter 16, but, as Weeks acknowledges from the start, this is primarily a rewrite of the original work by Hibler (2004). The chapter provides a good introduction to the topic, but someone serious about dynamics should look to additional contemporary works (e.g. Leppäranta, 2005; McPhee, 2008) for more in-depth and pedagogic information.

Chapters 5–8 delve into the material structure of sea ice, which is both an extensive area and an area of expertise of the author. A close study of these chapters is recommended to anyone trying to familiarize themselves with small-scale material properties. Chapter 5 begins at the smallest scales, from hydrogen bond interactions to molecular dislocations. Chapter 6 provides a fundamental discussion on the phase diagram of sea ice, which is very important for beginners because water (especially sea water) does not behave like

https://doi.org/10.3189/2011JoG10J155 Published online by Cambridge University Press

most other materials near the phase transition from liquid to solid. Additionally, the freezing process defies all oceanographic standards by separating out the different ion species at different temperatures, thereby altering (frozen) water mass composition. The resulting thermochemical relationships have significant effects on emissivity and therefore electromagnetic properties, especially in the microwave frequencies. Chapter 7 moves up in scale again to cover the visible structure of ice from crystal formations, grain boundaries and ice-floe structures. Weeks has kept up to date with topics including the issue of false bottoms and the freshening of summer ice in melt ponds, both of which are impacted as much by the dissolving of ion components as the melting of the ice crystalline structure. Chapter 8 addresses the main difference between sea ice and all other forms of ice: salinity. It deals with the classic issues of brine drainage and Poiseuille flow as well as the flooding and flushing that impact not only individual ice layers but also ridges and the overlying snow cover. Again, this is an area in which Weeks has considerable expertise, so he has kept up with the subject matter including recent developments in mushy-layer and percolation theory.

Chapters 11–15 and 17 cover a range of sample topics that are fundamental for modeling and remote sensing. Chapter 11 deals with polynyas and leads, chapter 12 with deformation, chapter 13 with sea-ice–sea-floor interactions, chapter 14 with the marginal ice zone, chapter 15 with snow, and chapter 17 with underwater ice (specifically platelet and marine ice). These chapters provide a solid foundation for trying to understand these topics, but Weeks has relied primarily on older classic works, and inquiries into more recent advances (especially since 2000) are recommended.

The wealth of comprehensive historic knowledge provided in chapter 10 makes clear that remote sensing and modeling today could not exist without the in situ and laboratory efforts recounted in these chapters. These are the chapters in which Weeks displays his greatest strengths, developed with the financial support of millions-of-dollars-per-day field programs during the 'golden age' of sea ice in the 1970s and 1980s. The literature and concepts conveyed in these chapters largely derive from that era. Conversely, there are very few citations from the author on the important topics covered in Chapters 3 (oceanography) and 14 (the marginal ice zone). The author did research in these areas but the results did not make it into the public-domain literature. Chapter 12 is a mixed bag, with good coverage of material deformation at the field scale but lacking from a remote-sensing and large-scale modeling perspective (which is addressed better in chapter 16 and referenced papers therein). Again, Weeks acknowledges his personal preference for citing those topics of which he has the strongest understanding. Finally, he is a strong advocate of more fieldwork, as this component of sea-ice research has significantly diminished relative to remote-sensing and modeling programs over the last two decades.

One contemporary book not referenced which complements this work is Eicken and others (2010; see book review, this issue), especially for those who wish to engage in fieldwork. But overall, Weeks's book is a well-written historic overview of the field and an excellent reference for those trying to understand sea ice in depth for the first time. It is also a real bargain. Most of the figures are reproduced in black and white in an effort to keep publishing costs down to maximize affordable knowledge dissemination. Don't be deceived by the lack of flashy color. The book is an excellent reference for anyone wishing to fill in missing knowledge gaps especially through the early years up to 2000. The quotations that appear throughout the book range from the profound to motivational kick-in-the-tail sayings. This book will sit well next to the classic Untertsteiner (1986) NATO reference.

REFERENCES

Eicken, H., R. Gradinger, M. Salganek, K. Shiasawa, D. Perovich and M. Leppäranta. 2010. *Field techniques for sea ice research*. Fairbanks, AK, University of Alaska Press.

Hibler, W.D. 2004. Modeling the dynamic response of sea ice. *In* Bamber, J.L. and A.J. Payne, *eds. Mass balance of the cryosphere: observations and modelling of contemporary and future changes*. Cambridge, Cambridge University Press, 227–334.

Leppäranta, M. 2005. *The drift of sea ice*. Berlin, etc., Springer-Verlag.

McPhee, M. 2008. *Air–ice–ocean interaction: turbulent ocean boundary layer exchange processes*. New York, Springer.

Untersteiner, N. 1986. *The geophysics of sea ice*. London, etc., Plenum Press. (NATO ASI Series B: Physics 146.)

Cathleen GEIGER

Department of Geography
University of Delaware
216 Pearson Hall
Newark
Delaware 19176, USA
E-mail: cgeiger@udel.edu

https://doi.org/10.3189/2011JoG10J155 Published online by Cambridge University Press