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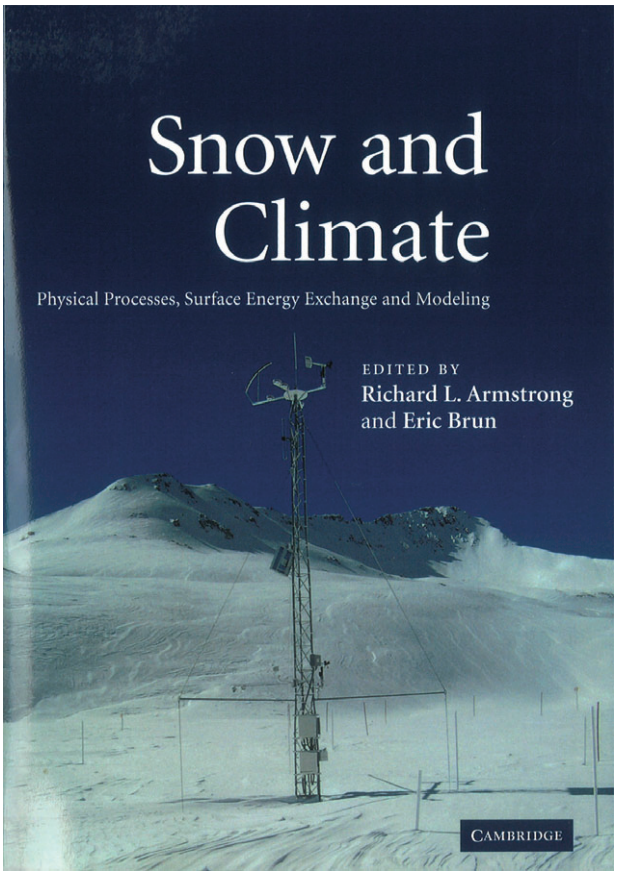
BOOK REVIEW

Review of *Snow and climate: physical processes, surface energy exchange and modeling*, edited by Richard L. Armstrong & Eric Brun (2008). Cambridge: Cambridge University Press. 222 pp. ISBN 978-0-521-85454-2.



At its peak extent, snow can cover more than 40% of the Northern Hemisphere land surface, greatly affecting surface exchange processes, and hence global climate. Snow is one of the most dynamic surface types and its distinct physical properties imply that it requires special attention when modelling short-term weather conditions and long-term climate. Natural hazards such as avalanches, reduced visibility from blowing snow, and snowmelt-induced flooding all necessitate the precise monitoring and modelling of snowpack evolution and attendant atmospheric conditions. It is therefore critical that we develop a better understanding of snow accumulation/ablation processes and their impacts on climate.

Snow and climate is certainly a welcome addition to the growing literature on this topic. It features five chapters written by 16 leading experts in snow and climate research. The preface reveals that the idea for the book arose from a meeting of the International Commission on Snow and Ice held in Victoria, British Columbia, in 1996. At the time of the meeting, few updated references on the topic of snow and climate were available since the publication of the *Handbook of snow*, or what I call the "Bible of snow", in 1981 (Gray & Male 1981). This gap in the literature motivated the participants of the meeting to develop the framework for a new text that would provide updated information on the topic of snow and climate. With the rapid development of atmospheric and hydrologic numerical models, as well as the emergence of remote sensing products of snow, this text is indeed well warranted. The book is most appropriately dedicated to the memory of Dr Donald M. Gray, one of the editors of the *Handbook of snow*, and a contributor to Chapter 3, who recently passed away after an illustrious career as a snow researcher in Canada.

The first chapter provides an introduction on snow and climate. It summarizes some of the basic physical characteristics of snow and its role in the climate system. This chapter also emphasizes the important role of snow in natural systems, including humans. It then introduces the implications of climate change on snow, along with the critical snow–albedo feedback, and its contribution to amplified warming at high latitudes and altitudes.

Chapter 2 discusses the physical processes within the snow cover and how these are parameterized in snow models. It begins with a thorough review of snow formation processes, including the atmospheric conditions that lead to the many types of snowflakes. Following snowfall, snow accumulates on the surface where it quickly evolves in response to ambient conditions. Here the authors provide comprehensive information on snow metamorphism processes such as compaction, water vapour diffusion, and liquid water infiltration and refreezing. It also reviews the radiative properties of snow that are so essential to the climate system.

The following chapter focuses on the mass balance of snow and the exchanges of heat and moisture between the atmosphere and the snow cover. It reviews the equations of surface energy and mass balances, including the

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role of shortwave and longwave radiation and the turbulent fluxes. There is also a discussion on the impacts of vegetation, wind and terrain on snow accumulation and ablation. This chapter also provides very useful and clearly illustrated examples of the evolution of snowpack and atmospheric conditions at alpine, subalpine, Arctic sea-ice, prairie and boreal forest sites.

Chapter 4 discusses the rapidly developing field of snow-cover parameterization and modelling. A history of the development of snow models leads to a description and an intercomparison of recent snow models. The sensitivity of a snow model to various parameters such as the prescribed albedo, water retention, turbulent fluxes and snow–rain criterion is investigated. The parameterization of snow in global climate models then follows, including the role of the snow–albedo feedback on climate change projections.

The final chapter summarizes snow-cover measurements, data products and sources. It reports the various techniques used to track the in situ snow state, including snow depth, density, water equivalent and stratigraphy. The rapidly emerging field of remote sensing of snow is then discussed, along with a description of the various satellite platforms, sensors and products. Details on the development of various operational snow products that have recently emerged in response to the growing societal demands for up-to-date snow information close the final chapter.

The text is well written, and it targets an audience of snow and climate researchers as well as advanced students. The illustrations are all clear, but there are only a dozen or so colour plates that are somewhat inconveniently found in the middle of the book. Prior to the introduction, there is a useful table listing the nomenclature used in the text. A list of references (sometimes containing errors) follows each chapter. The strength of the book lies in its presentation of the science, particularly when it comes to snow formation, accumulation and ablation processes. An appropriate level of mathematics and illustrations support the ideas and topics developed in the text. As such, it will undoubtedly become a very useful reference to the target audience.

A weakness of this effort is the coverage of the broad topic of climate and its relation to snow. The book would have been improved with the inclusion of a chapter dedicated solely to the climatology of global snow-cover extent, duration and accumulation. There is little, if any, discussion on the role of snow on teleconnections, such as the close relationship that exists between the snow-cover extent of Eurasia and the monsoons of south-east Asia or the hydroclimate of North America. The text also lacks a comprehensive discussion of the interactions between snow and climatic oscillations, such as the El Niño/Southern Oscillation or the Arctic Oscillation. There is also scant information on the role of snowmelt in generating streamflow, an important source of freshwater on a global scale. Curiously the book ends without a conclusion to sum up and link the main topics covered in the text.

Despite these weaknesses, *Snow and climate* provides an accurate and updated snapshot of our knowledge on this important topic. It will certainly serve as a useful reference for any upper level undergraduate or graduate course focusing on the cryosphere. It will also undoubtedly become an asset for climate modellers, atmospheric scientists, snow hydrologists and glaciologists who are interested in the topic. Thirty years after the publication of the *Handbook of snow*, we finally have a new resource for important information on snow and climate.

Reference

Gray D.M. & Male D.H. 1981. *Handbook of snow*. Toronto: Pergamon Press.