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Book review: Mark Serreze and Roger Barry. "The arctic climate system" (2nd. edition)

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The Arctic Climate System Second Edition. Mark Serreze and Roger Barry. 2014. Cambridge University Press. 404 p, illustrated hard cover. ISBN 978-1-107-03717-5. £75.00

While the Arctic sits in uncertain times experiencing amplified warming and rapid change, there is no better time for the Arctic Climate System (second edition). It brings an overview of climate interactions between atmosphere, land and ocean, detailing the complex systems at play. A wealth of knowledge is brought to this book by the authors, Mark Serreze and Roger Barry, who have dedicated their careers to climate research in the high latitudes. Originally published almost a decade ago, the second edition is a welcome update reflecting the recent advances in both understanding and observational research programmes. The result is a highly informative and detailed publication, which remains engaging throughout.

Comprising of 11 chapters, the reader is taken on a journey from early scientific exploration in the 16th century, to the latest global climate models used to predict the climate for centuries to come. A solid background to the Arctic is given in the first three chapters. I found the summary of historical exploration particularly insightful, detailing the perils of early scientists who discovered the wilderness of the north. Contemporary research takes a different tone, focussed on understanding specific processes, interdisciplinary interactions, and forecasting future climate. The connections between land, ocean and climate in the Arctic are explored in chapter two. The regional perspective is up scaled with the Arctic being placed into a global context regarding atmosphere, ocean and energy budgets in chapter three. Accessible and interesting, these chapters cover the basics of the Arctic climate and are suitable for any interested party.

Those with specific interest in the Arctic climate will benefit from the following five chapters, which focus on specific processes and their implications. The following are all covered in detail: atmospheric circulation, surface energy budgets, precipitation, and sea ice. Particular attention is paid to the intense seasonal variability of each of these aspects and how this impacts the wider climate system. Substantial attention is paid to albedo and radiative forcing, leading into discussion of radiation – climate feedbacks. Schematic diagrams delineate the key feedback mechanisms, illustrating the positive/negative interactions between elements. These, together with descriptions within the text offer a solid understanding of the complex and evolving climate, forming a valuable resource to support learning and teaching. A solid overview of the key processes and interactions of the Arctic climate system is well presented and will benefit anyone undertaking research into the changing Arctic.

Serreze and Barry have made a concerted effort to intertwine the current changes to the Arctic climate throughout the book. This approach continually reinforces that the change is not solely constrained to one discipline or geographical region. The rate of change is often put into context: “During July 2012 more than 98 percent of the ice sheet experienced at least a brief period of surface melt... the last time that such extensive melt occurred was in 1889 and next previous event was approximately seven centuries earlier.” (Ngheim et al., 2012). A comparison such as

this is a stark reminder that we are living in a time of change, promoting the need to learn what the implications are, both for the Arctic and globally.

Much of this understanding is coming from climate models, which are explained in a dedicated chapter. As the primary tool for forecasting future climate, models are becoming increasingly complex, requiring ever more computing power. The authors review the types of models, their uses and limitations in a way that remains understandable. This is quite a feat! From single column to global climate models (GCM), descriptions and applications are given, as well as examples of existing models. GCMs receive substantial attention due to their use in the Intergovernmental Panel on Climate Change (IPCC) reports. Of course, there is not just one GCM but many. The book draws upon the coupled model intercomparison projects, which strive to acknowledge and quantify the limitations and variability within different models.

The penultimate chapter discusses paleoclimates, placing the contemporary climate in a greater temporal context. Methods of obtaining and reconstructing past climatic conditions are explored. Whilst the Arctic has undergone unconceivable change in the geologic past, the authors present a concise review of glacial cycles, enabling the current rate of change to be put into perspective. Anyone studying change in the Arctic should be mindful of the temporal scales of natural variability when discussing current and future change. The consideration of past climates leads into "The uncertain future", a thought provoking and somewhat sombre final chapter. Bringing together all the topics covered in the book, an overarching assessment of change, and predicted change is presented. A valuable summation of the gaps in understanding is presented in a manner that would make any interested student or researcher eager to learn more and tackle the challenge of predicting future change in the Arctic.

The volume is embellished with 32 full colour figures illustrating the latest research findings in addition to detailed schematics to clarify key processes throughout the book. Focus questions and exercises are found at the end of each chapter, designed to reinforce the readers understanding of topics covered. This will be particularly beneficial for students. The text is complimented with essential equations in addition to graphs and diagrams illustrating key points. The authors have included tables of key values, such as the thermal conductivity of natural materials (chapter 5), providing a valuable resource. In many occasions, results from observational research form the basis of explaining certain processes. For example, results from SHEBA (Surface Heat Budget of the Arctic Ocean) are used to explain radiation fluxes and their temporal and spatial variability. We are reminded of the temporal and spatial limitations of observational studies; many studies only last a few years, and geographical limitations put constraints upon observations e.g. sparse distribution of precipitation measuring stations above 60° north (chapter 6). Remote sensing overcomes these obstacles, to an extent, and has allowed for continuous monitoring of sea ice extent over the last 30 years. Since the first edition of the Arctic Climate System, sea ice research has progressed in leaps and bounds. This chapter boasts many figurative illustrations from satellite data, recently updated to 2012.

There are however a few graphs which do not include the 21st century. Looking to the future of remote sensing, the expected launch of ICESat-2 in 2017 is mentioned giving longevity to the relevance of this volume for many years to come.

The Arctic Climate System (second edition) is an essential resource for all students and scientists engaged in Arctic research, now and for years to come. Drawing upon the authors' wealth of knowledge, readers will appreciate this thorough and engaging text. Provided within this volume is an Arctic climate tool kit: the key processes and physical dynamics that drive the Arctic climate system is discussed in detail, the complexity of the natural system is dealt with piece by piece, and contemporary change is considered throughout. No book could ever cover every detail of the Arctic climate, which makes the reference list within a valuable resource. Rich in citations, readers will be guided to essential literature that has shaped our understanding of the Arctic climate system to further their learning.

Nghiem, S. V., Hall, D. K., Mote, T. L., Tedesco, M., Albert, M. R., Keegan, K., & Neumann, G. (2012). The extreme melt across the Greenland ice sheet in 2012. *Geophysical Research Letters*, 39(20).

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