

READINGS

BOOK REVIEWS

THE DEVELOPMENT OF ATMOSPHERIC GENERAL CIRCULATION MODELS: COMPLEXITY, SYNTHESIS AND COMPUTATION

Leo Donner, Wayne Schubert, and Richard Somerville, Eds., 2011, 272 pp., \$85.00, hardbound, Cambridge University Press, ISBN 978-0-521-19006-0

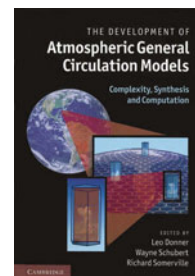
This book starts out with a depiction of the emergence of atmospheric general circulation models (AGCMs), and continues with descriptions of their later evolution. Written by a group of major players in atmospheric sciences, this book contains a fascinating account of what happened at the very dawn of numerical weather prediction—most of which is rarely found in the literature—as well as discussions on the current course of AGCM development and prospects for the future.

This is a book suited for general readers who want to know how atmospheric general circulation models were first conceived and how their development was propelled by scientific advances and rigorous efforts of a few key people. It is also a book for those who want a glimpse of the present status of AGCMs, with an eye on their future development. But by and large, this is a book on the history of the science of AGCMs. When I opened the book, I could not help but read it from the beginning to the very end in a single go.

The chapters of the book connect some lesser-known but important links in the historical chain of events leading to the atmospheric model development. In 1945, several things happened at almost the same time: Vladimir Zworykin of the electronic company RCA, inventor of television transmitting and receiving devices, imagined human intervention in weather through computer calculations in his pamphlet on “Modern Computing Devices” and the flamboyant “Outline of Weather Proposal” (this was at the time of the nuclear bomb—the Manhattan Project); John Mauchly of the University of Pennsylvania, inventor of computers, went to the Weather Bureau to seek examples of weather applications using the EDVAC computer; John von Neumann, who collaborated with Mauchly and interacted with Zworykin, wrote the architecture of computers. In January 1946, Francis Reichelderfer, chief of the Weather Bureau, convened a meeting with Zworykin,

von Neumann, Harry Wexler, and a few others to discuss the subject. Wexler’s professor at MIT, Carl Rossby, started to interact with von Neumann in early 1946, and suggested that the Institute for Advanced Study (IAS) submit a proposal that he outlined on weather research to the Navy Office of Research and Invention (ORI). Von Neumann submitted the proposal on 7 May 1946 and ORI funded it on 19 July 1946. The content of the proposal, significantly influenced by Rossby with emphasis on science rather than premature applications, is still amazingly relevant to what is occurring at present: “. . . to examine the foundations of meteorology, to solve the basic problems of the general circulation, and to improve our understanding of atmospheric processes.” Also relevant to the present was an apparent underestimation of the complexity of the research at hand, because by the end of 1947, the project was waning down. It was at that time von Neumann and Wexler, with the help from Rossby, recruited Jule Charney and a few other young people to rejuvenate the project. The infusion of new energy and talent bore fruit: In 1950, Charney, Ragnar Fjørtoft, and von Neumann successfully produced the first calculation of the 500-hPa geopotential height with 24-hour lead time, setting the landmark of numerical weather prediction, while in 1955, Norman Phillips demonstrated the simulation of the general circulation, laying the milestone for the development of atmospheric general circulation models.

Readers of this book will also take notice that Charney’s 1950 model used 19-by-16 horizontal grid points with a spatial resolution of 736 kilometers and a single layer, while Phillips’s model used 16-by-17 grid points with two layers for a beta-plane channel of the whole atmosphere. Both models used



equations of balanced flows, after taking a lesson from Richardson's experience in trying to solve the primitive equations directly. This is a good example of where advances in the theoretical understanding of large-scale atmospheric circulations profoundly impacted the successes of numerical models. Charney's work prompted the establishment of the Joint Numerical Weather Prediction Unit of (JNWPU) of the Weather Bureau and the military Weather Services—which was the predecessor of the present National Center for Environmental Prediction (NCEP). Phillips's work prompted the establishment of the General Circulation Research Section in Washington, D.C. [now the Geophysical Fluid Dynamics Laboratory (GFDL) at Princeton University].

The account of history in the book is a record of imagination and pursuits, expectations and setbacks, reinvigoration and triumph. The process of how sciences are shaped by individual people and events is vividly described with great details. For people who wonder about the future direction of current research on anthropogenic climate change, this book should be a useful source of reflection and inspiration, just as Winston Churchill said: "The farther backward you can look, the farther forward you are likely to see."

The book also contains a chapter on the coevolution of climate models with the Intergovernmental Panel on Climate Change (IPCC). Like the giants in

early history, it is the courage and foresight of a few key individuals that initiated the IPCC—another era in atmospheric modeling. One of these giants was Bert Bolin, who served as chairman of the IPCC between 1988 and 1997. Twenty days before his death, the Norwegian Nobel Committee awarded the 2007 Nobel Peace Prize to the IPCC.

Complementing the historical flavor of the initial chapters, the book includes some modern topics on the crossing paths of numerical weather prediction and climate modeling, the use of observational data to constrain models, and numerical techniques in the digital age. These chapters are good references for people engaged in active research, and can be read separately as standalone material. The book also highlights the development trajectory of the coupling of atmospheric models with the oceans, and the coupling with land surfaces; however, these chapters are relatively brief.

This book is not a textbook. The scope and depth of the chapters are uneven. While some chapters are easy to follow by any reader with a basic scientific background, others contain sophisticated material with the intricacy of review articles in peer-reviewed journals. By necessity, the book cannot possibly cover all the topics on the development of atmospheric models. But in view of the current ongoing activities with Earth system models, it would be nice and timely to see future editions of the book include accounts

NEW PUBLICATIONS

ENCYCLOPEDIA OF SNOW, ICE AND GLACIERS

V. P. Singh, P. Singh, and U. K. Haritashya, Eds., 2011, 1,253 pp., \$549.00, hardbound, Springer, ISBN 978-90-481-2641-5

This title provides current information and discusses basic concepts on snow, ice, glaciers, and other cryospheric branches. Topics covered include atmospheric processes responsible for snow formation; transformation of snow to ice and changes in their properties; classification of ice and glaciers and their worldwide distribution; glaciation and ice ages; glacier dynamics; glacier surface and subsurface characteristics; hydrology and sedimentary systems; permafrost degradation; hazards caused by cryospheric changes; and global-scale trends of glacier retreat.

NAVIGATING GRADUATE SCHOOL AND BEYOND: A CAREER GUIDE FOR GRADUATE STUDENTS AND A MUST READ FOR EVERY ADVISOR

S. A. Christopher, 2011, 157 pp., \$28.00, paperbound, American Geophysical Union, ISBN 978-0-87590-736-9

This book outlines the steps and skills necessary to succeed in graduate school and in starting a career. The author, an atmospheric science professor, provides "insider tips" to help students better understand their advisors, leading to more productive advisor/student relationships. He also details other good habits and management techniques that can help students get ahead in areas such as time management, writing and communicating, and job hunting.

THE OXFORD HANDBOOK OF CLIMATE CHANGE AND SOCIETY

J. S. Dryzek, R. B. Norgaard, and D. Schlosberg, Eds., 2011, 727 pp., \$150.00, hardbound, Oxford University Press, ISBN 978-0-19-956660-0

This handbook addresses questions of how climate change affects human systems, and how societies can, do, and should respond. Key topics covered include the history of the issues, social and political reception of climate science, the denial of that science by individuals and organized interests, the nature and economics of the social disruptions caused by climate change, questions of human security and social justice, policy instruments for reducing greenhouse gas emissions, and governance at local, regional, national, international, and global levels.

of the development of atmospheric chemistry and aerosol models, and to expand on its current content on the coupling of atmospheric models with biogeophysical and biogeochemistry models.

All in all, this book is a delight to read and to own.

—MINGHUA ZHANG

Minghua Zhang is professor of atmospheric sciences and dean of the School of Marine and Atmospheric Sciences

at the Stony Brook University of the State University of New York (SUNY). He currently serves as cochair of the Atmospheric Modeling Working Group (AMWG) of the Community Earth System Model (CESM).

FOR FURTHER READING

Zworykin, V. K., 1945: Outline of Weather Proposal.

RCA Laboratories, 12 pp. + appendices. [Reproduced in full in *History of Meteorology*, 4, 57–78.]

MACHINE LEARNING METHODS IN THE ENVIRONMENTAL SCIENCES: NEURAL NETWORKS AND KERNELS

William W. Hsieh, 2009, 364 pp., \$75.00, hardbound, Cambridge University Press, ISBN 978-0-521-79192-2

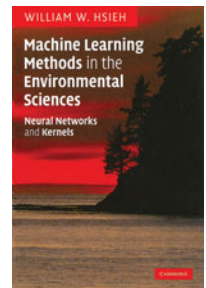
The evolution of the field of machine learning has been somewhat organic, involving contributions from numerous other fields, including mathematics, physics, statistics, and—mostly by virtue of the latter—the environmental sciences. However, at some stage during that evolution, some inexperienced practitioners in the environmental sciences began a practice of misuse and misapplication that extends to the present time. As such, Hsieh's book is timely because it provides an important service to both fields by presenting machine learning to an audience of environmental scientists with precision and rigor.

The rigor is not prohibitive. Hsieh strikes a comfortable balance between rigor and readability.

Every equation is accompanied by a thorough explanation of its derivation and meaning, and every graph is clearly explained in plain language.

As a text book, the level is appropriate for beginning graduate students and advanced undergraduates, preferably with some knowledge of college-level algebra and calculus. However, the thorough explanations in plain language make the book reachable even for the less mathematical reader.

The book is ideal and unique as a text book for a course on machine learning methods and applications



ENVIRONMENTAL HAZARDS: THE FLUID DYNAMICS AND GEOPHYSICS OF EXTREME EVENTS
H. K. Moffatt and E. Shuckburgh, Eds., 2011, 332 pp., \$86.00, hardbound, World Scientific, ISBN 978-981-4313-28-5

This volume focuses mainly on tropical cyclones, tsunamis, monsoon flooding, and atmospheric pollution, all within the context of climate variability and change. It provides an introduction to these topics from both mathematical and geophysical points of view. Areas examined include vortex dynamics and turbulence, geophysical and environmental fluid dynamics, the hurricane–climate connection, transport and mixing of atmospheric pollutants, and tsunami modeling and forecasting techniques.

TERRESTRIAL HYDROMETEOROLOGY
W. J. Shuttleworth, 2012, 448 pp., \$99.95, paperback, Wiley-Blackwell, ISBN 978-0-470-65937-3

This graduate-level introductory text on the emerging discipline of hydrometeorology is appropriate for both hydrology departments to teach relevant aspects of meteorology and meteorological departments to teach relevant aspects of hydrology. Topics covered include water vapor and vertical gradients in the atmosphere, surface energy fluxes, terrestrial radiation, general circulation models, global-scale influences on hydrometeorology, formation of clouds and precipitation, equations of atmospheric and turbulent flow in the atmospheric boundary layer, precipitation analysis in time and space, and daily evaporation estimates.

GLOBAL CLIMATE CHANGE: A PRIMER
O. H. Pilkey and K. C. Pilkey, with art by M. E. Fraser, 2011, 142 pp., \$19.95, paperback, Duke University Press, ISBN 978-0-8223-5109-2

After explaining the greenhouse effect, this book then discusses the damage it is causing: sea level rise, ocean acidification, glacier and sea ice melting, changing habitats, desertification, and the threats to animals, humans, coral reefs, marshes, and mangroves. These explanations are accompanied by artwork depicting the large-scale arenas in which climate change plays out. The authors also directly confront and repudiate arguments typically advanced by global change deniers.

in the environmental sciences. It is abundant with examples from satellite remote sensing, atmospheric science, climate science, oceanography, hydrology, and ecology. Although many of these topics have been covered in other compilations such as conference proceedings, the single-authored nature of Hsieh's book endows it a unified connectedness that is unique.

Unlike many other books on machine learning, Hsieh's book has a healthy dose of statistics—a welcome homage to the origins of the field of machine learning. Still, this reviewer would have liked to see more topics from elementary statistics, such as hypothesis testing and interval estimation. As such, if the text is to be used as an undergraduate text, students may benefit from a brief introduction to statistical inference, to supplement the early chapters of Hsieh's book.

The inclusion of the advanced topics also makes the book useful for researchers in the environmental sciences. Hsieh manages to gingerly handle topics from which many authors turn away. The organization of the book conveys a sense of natural flow

that, in turn, mutes the complexity of the topics. The utility of the book as a research text is strengthened by the self-contained nature of many (especially, the latter) chapters.

The specific topics covered in the book are avant-garde. They range from basic multivariate statistics and time series analysis to some of the most sophisticated topics in statistics and machine learning, including neural networks, support vector machines, Bayesian classifiers, and Gaussian processes. Most importantly, there are several sections that highlight the importance of using the correct methods for assessing the performance of the various algorithms. There is even a section on the assessment of probabilistic forecasts, a topic of extreme significance in prediction problems with an economic component (although it is not clear to this reviewer why this section appears in the chapter on nonlinear regression.)

The appendices list websites for downloading computer code and data sources. These allow the reader to easily apply the methods in the book to one's own

datasets. An extensive bibliography, especially on the application of machine learning methods to environmental sciences, offers the reader ample opportunity to find connections between published literature and one's own work. At the end of each chapter, there are numerous exercises designed to develop problem-solving skills for the students. There is even a course website, containing several datasets that arise in the exercises. The website also provides updates to the book.

In summary, this reviewer enthusiastically recommends Hsieh's book to anyone interested in a statistically well-founded book on the application of machine learning techniques to the environmental sciences. There is simply no other book like it!

—CAREN MARZBAN

Caren Marzban is an instructor in the Department of Statistics, and a senior physicist in the Applied Physics Laboratory, both at the University of Washington in Seattle.

REANALYSIS

Looking back at "News and Notes" in the Bulletin of November 1974:

BIRTH OF THUNDERSTORMS LINKED WITH DRYLINE

The dryline phenomena separating dry desert wind from moist air in the lee of the Rocky Mountains appears to mark a favored location for thunderstorm development over the southern Great Plains, according to Joseph T. Schaefer of the National Severe Storms Laboratory. . . . Schaefer says the invisible dryline occurs most frequently in west Texas and Oklahoma during the spring and early summer. Approximately paralleling the terrain contours, the dryline is sometimes observed as far north as Nebraska and the Dakotas.

By studying the development and progression of actual dryline events, the NOAA meteorologist developed a numerical model to determine the life cycle of the dryline and the cause of its motion. Computerized results indicate that the daytime movement of the invisible dryline is determined by surface heating of the Earth, causing vertical mixing of dry and moist air, rather than by naturally occurring westerly winds. The question of why the dryline is a preferred location of thunderstorm generation remains unanswered.

The importance of the dryline as a severe weather predictor has been recognized for almost a quarter of a century. A recent four-year study of radar echo formation showed that when cells existed within 370 km on either side of the dryline, 78 percent of the first radar echoes developed within 19 km of the dryline position.

The United States is not the only country to experience dryline-like occurrences. Over India and central West Africa the dryline is a significant feature during the pre-monsoon months. These phenomena are similar to their United States counterpart in terms of amount of heating at the Earth's surface, the vertical profile of the dryline, and its effect upon convection.

—*Bull. Amer. Meteor. Soc.*, **55**, 1379