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Book review

Vilà-Guerau de Arellano, J., van Heerwaarden, C.C., van Stratum, B.J.H., van den Dries, K., 2015. Atmospheric Boundary Layer, Integrating Air Chemistry and Land Interactions, Cambridge University Press, New York, NY, USA. Hardcover, 265 pp. Price $79.00. ISBN 978-1-107-09094-1

Atmospheric Boundary Layer by Vila-Guerau de Arellano and colleagues employs an interactive learning method to introduce readers to the atmospheric boundary layer (ABL) and its role as a region that connects surface processes to larger-scale atmospheric processes. This book challenges readers to move beyond their specific disciplines to establish connections and explore links among the fields of atmospheric dynamics and chemistry, land surface processes, and biogeochemical cycles in the land processes in order to understand their interactions and feedbacks. Following the authors' mottos of *learning and asking through questions* and *theory meets practice,* the stated intention of this book is to offer an interactive learning method. This interactive nature comes in through the modular structure of the book, where readers can select and design a theme of study according to their interests. But more importantly, it comes in through the hands-on exercises throughout the book that rely on the interactive software, Chemistry Land-surface Atmosphere Soil Slab (CLASS).

The authors' focus is the understanding and representation of the diurnal atmospheric boundary layer, namely the convective boundary layer (CBL), which forms between sunrise and sunset. They use the well-mixed conditions of the CBL to allow for a simplification of the CBL as a bulk layer, where atmospheric variables and compounds are nearly constant with height. The authors derive mixed-layer budget equations, where variable quantities depend on surface and entrainment fluxes and boundary layer height. Additional terms may be added in the cases of, for example, advection or reactive species. CLASS applies the budget equations within the ABL to calculate the evolution of each variable in time. The derivation of the mixed-layer equation can be found in Chapters 2 and 4, with the full derivation provided in Appendix A.

Organizationally, the book is divided into five main parts. Part I provides an overview of the approach of the book and introduces the fields that are being crossed: atmospheric dynamics, atmospheric chemistry and air pollution, land surface processes, and biogeochemical cycles in the land processes. The authors note that a primary objective of this book and the CLASS software is to actively learn how to ask and answer a research question using numerical experiments. To this end, of particular value to students, the authors include a Section in Chapter 1 that provides a roadmap of how to design a research plan. In addition to following the exercises in the book, it provides readers a framework with which to design their own experiments.

Parts II through IV combine theory with practice. Nearly every chapter begins by introducing fundamental concepts and equations and concludes with hands-on exercises. Part II is devoted to the uncoupled system, which includes chapters on ABL dynamics and chemistry (Chapters 2 & 3), the potential temperature, moisture and momentum budgets (Chapters 4–6), and the scalar and reactant species budgets (Chapters 7 & 8). Part III builds upon the previous chapters and moves on to the coupled system. Chapter 9 describes the interactions among vegetation, soil, and the ABL, and is followed by entire chapter (Chapter 10) devoted to land-atmosphere hands-on experiments. Chapter 11 introduces empirical expressions to represent the exchange of CO_2 between the land and the atmosphere, and Chapter 12 is a hands-on chapter that explores the sensitivity of the land-atmosphere system to climate perturbations. Although experimental changes to the large-scale system, such as warmer temperatures or high CO_2 concentrations, occur on larger timescales than can be studied with CLASS, the CLASS model can be used to study how small-scale and short-term processes respond to large-scale climate perturbations. Chapter 13 explores more complex case studies, such as sea breeze interactions and multi-day drought and pollution events. Part IV is focused on processes related to boundary layer clouds, divided into two chapters for stratocumulus clouds (Chapter 14) and shallow cumulus clouds (Chapter 15).

Part V is the user's guide to CLASS, including a description of the modules and variables. The reader should begin with this chapter (Chapter 16) before performing the hands-on experiments suggested in previous chapters. URLs are provided in the beginning of the book where the reader can download the software and access additional teaching and learning tools, including instructional videos, figures for Powerpoint presentations, and solutions to numerical experiments.

While the organization of the book systematically introduces readers to the individual processes and the interactions among them, the book has a flexible structure. The authors propose example themes to guide the study of different interests. They then provide a roadmap of recommended chapters, building up from the fundamentals to higher levels of complexity. Understanding that readers may be interested in exploring certain subjects further, the authors include a list of references for readers to deepen their understanding. Additionally, each chapter ends with suggested reading to dive deeper into the topics covered in that chapter.

While providing an introduction to the atmospheric boundary layer and the interactions and feedbacks within the land-atmosphere system, Dr. Vila-Guerau de Arellano and colleagues have created a valuable teaching and learning tool. The CLASS software guides and inspires active learning, and is straightforward to acquire and use. I recommend this textbook and software for undergraduate and graduate students, and as a reference for researchers in fields ranging from plant physiology to atmospheric science.

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