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Models for tropical climate dynamics. Waves, clouds, and precipitation. (English)

Zbl 1428.86010

Mathematics of Planet Earth 3. Cham: Springer (ISBN 978-3-030-17774-4/hbk; 978-3-030-17775-1/ebook). xvi, 303 p. (2019).

This interesting didactic monograph includes many results of author's own research activities in the field of modelling tropical climate dynamics. This includes theoretical as well as computational approaches in constructing specific physical models, analyses of solutions of their essential equations, and discussions regarding applicability of the considered models in explaining and prediction of real meteorological events, primarily those located at low latitude tropical regions.

The book is written in a clear way, with necessary mathematical derivations, details of numerical treatments, and a large number of instructive exercises. The text written in 16+303 pages is divided into 3 Parts dealing with background and preliminaries (Chapters 1–4), the deterministic multi-cloud modelling (Chapters 5–9), and the stochastic multi-cloud modelling (Chapters 10–12), respectively. Finally, Glossary, References, and Index are the chapters that conclude the book.

The introductory Part I comprise four chapters with theoretical essentials needed in studies of atmospheric phenomena in low latitude tropospheric regions. In this sense, Chapter 1 offers basic hydrodynamic equations for dry air which includes wave phenomena like trapped waves, vertical normal modes, and shallow water wave approximation, among others. In Chapter 2, the considered medium composition is upgraded by inclusion the water component in all three states: solid, liquid, and gas with possibility of phase transitions. Chapter 3 offers observational facts about tropical climate dynamics including cloud formation, presence of wave patterns and coupling with convective motions. Basic elements of stochastic processes and related computational methods are introduced in Chapter 4.

Part II with Chapters 5–9 is focused on deterministic multicloud models in order to enlighten the complex dynamics of convectively coupled atmospheric waves in tropical regions. Thus, Chapter 5 contains details of the models involving moist gravity waves, stability criteria, and nonlinear simulations. In Chapter 6 the author uses the multicloud model to analyze the linear instability with congestus clouds as precondition, and provides some nonlinear simulations. More on convenctively coupled equatorial waves in the multicloud model is presented in Chapter 7, while Chapter8 gives details on vertical transport of horizontal momentum at turbulent motions with different scales. Chapter 9 discusses issues concerning implementation of the multicloud procedure in the considered climate model, and provides warm pool simulations with practical applications in equatorial climatology.

Part III comprises Chapters 10–12 and is devoted to more advanced multicloud models improved by introducing stochasticity into the scheme. So, Chapter 10 deals with birth and death models for convective inhibition and setting up a corresponding stochastic multicloud model for further practical applications, while Chapter 11 contains arguments for implementation of the model in global climate studies. The last Chapter 12 gives final analyses and sums up conclusions on applicability of the stochastic multicloud model in forecasting climate events such as monsoons, and others.

To conclude, this book is a result of author's activity in climate modelling and numerical analysis, over many years. It is a valuable literature not only for professionals in climatology, but also for graduate students as a useful text book with numerous examples of practical exercise.

Reviewer: Vladimir Čadež (Beograd)

MSC:

86A08	Climate science and climate modeling
86A10	Meteorology and atmospheric physics
86-02	Research exposition (monographs, survey articles) pertaining to geophysics
35Q30	Navier-Stokes equations
76E15	Absolute and convective instability and stability in hydrodynamic stability
76E30	Nonlinear effects in hydrodynamic stability
76E20	Stability and instability of geophysical and astrophysical flows
76U05	General theory of rotating fluids
76V05	Reaction effects in flows
76M35	Stochastic analysis applied to problems in fluid mechanics
62P12	Applications of statistics to environmental and related topics
60H35	Computational methods for stochastic equations (aspects of stochastic analysis)
62M86	Inference from stochastic processes and fuzziness
80A17	Thermodynamics of continua
82D05	Statistical mechanics of gases
82C21	Dynamic continuum models (systems of particles, etc.) in time-dependent statistical mechanics
82D30	Statistical mechanics of random media, disordered materials (including liquid crystals and spin glasses)
90C90	Applications of mathematical programming

Keywords:

atmospheric dynamics; atmospheric thermodynamics; multicloud models: deterministic and stochastic; global climate modelling; tropical climate; tropical modes of variability; wave-convection interaction; cloud dynamics

Full Text: DOI