Book reviews

Fundamentals of Atmospheric Dynamics and Thermodynamics by C.A. Riegel and edited by A.F.C. Bridger (World Scientific, 1992) ISBN 9971-978-87-3. 496 pp.

This is an unusual book for 1992. It's quite long (496 pages) and covers just the fields of dynamics and thermodynamics; yet it concentrates on the foundations of the subject such that 90 per cent of the book could have been written prior to 1960 (or even 1950). 'Modern' concepts, such as baroclinic instability, quasi-geostrophy and even Rossby waves, do not come in until the final chapter (admittedly making up 20 per cent of the book) titled 'Numerical Prediction and Large Scale Dynamics'.

The book is based on the lecture notes of C.A. Riegel for the undergraduate Dynamics and Thermodynamics course at San Jose University. According to the Preface, Professor Riegel was the mainstay of the dynamic meteorology program at that institution, and his lectures, developed over many years, were 'well-known to students and atmospheric scientists in the area for their rigour and clarity'. The book has thirteen chapters. One is introductory; chapter 2 is on mathematical preliminaries, such as jacobians, vector algebra, integral theorems, etc. These are followed by five chapters on kinematics, the equations of motion, geostrophic and gradient wind concepts, the continuity equation and vertical co-ordinates. Three chapters follow on basic thermodynamics, then one on parcel stability, one on circulation and vorticity, and one on numerical prediction and large-scale dynamics.

There is a role for such a book in modern meteorology. I have always loved the fundamentals of the subject, yet have found it frustrating that I have to use such a large variety of sources for information on these fundamentals. Thus, for example, over the years when needing to know the derivation and precise form of the equation for the moist adiabat, I've always referred to the relevant chapter of Brunt's 1939 text. When needing to refer to the relevant vector identities, I turn to the appendix of Haltiner and William's book on numerical weather prediction. When floundering with partial derivatives and z, p, log-p, theta and other vertical co-ordinate systems, there is a page I always turn to in Brand's *Advanced Calculus.* When wanting to know the expressions for vorticity and divergence in spherical or cylindrical co-ordinates, I refer to a scrap of paper in my desk's top drawer, and so on.

In fact I have 30 or so basic references I have to go to. The promise of Riegel's book is that all this type of information is presented in a logical order, under the one cover. The attempt is impressive, but for the information that I look up, in each case my normal reference is better. Another minor frustration with the book is that it tends to stop, or retreat, when it reaches the interesting point in any discussion or derivation. A number of examples will illustrate this. When dealing with the second law of thermodynamics, it simply states that the most efficient heat engine is one operating in a reversible cycle, without deriving that result. When presenting the form of the thermodynamic equation used in meteorology, it neglects to note that this equation is assuming reversible thermodynamics. On Rossby waves, it states the expression for group velocity, but doesn't point out it equals the derivative of frequency with respect to wavenumber.

So, in summary, I don't like the book very much. It covers much the same material as Haltiner and Martin's 1957 text, but the latter does a better job. We haven't had a 'Feynman' write on our subject yet, so for the student wanting an introduction to the fundamentals of the field, Haltiner and Martin is still probably the best reference for the thermodynamics. For the dynamics, probably the third edition of Holton's *Introduction to Dynamic Meteorology* should be used.

John McBride

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Global Atmospheric Circulations: Observations and Theories by Richard Grotjahn (Oxford University Press, 1993) ISBN 0-19-507245-6. $120.00.

The author states in his Preface that his goal in this text was to provide 'a comprehensive, cohesive, and notationally consistent description of the general circulation of the atmosphere.' For the most part he has succeeded in this. It is well written and presents its material in a logical and pleasing sequence. As the title implies, the author presents in the first half of the book observational information on the general circulation and then discusses the theories which explain these observations. The layout works quite well and effort is devoted to ensuring these parts are seen as complementary. Both the observations and the theories are broken up into chapters which examine the zonal and the nonzonal fields and that compartmentalisation makes the book flow nicely. The only chapter I felt was perhaps out of sequence was that devoted to 'Momentum and Energy Relations'. This chapter presents a considerable amount of mathematical development and invokes the concepts of eddy energy and transports even before the 'Observed Nonzonal Fields' are discussed. I felt this chapter more naturally belonged either incorporated into, or presented after, those dealing with the theories. In the book there is some repetition on these matters.

An attractive feature of the text is the early chapter dealing with the various methods by which the atmosphere is observed and a quantitative assessment of the limitations of these various techniques. These are important topics not often covered in monographs of this nature.

One criticism I have of the book is that many of the references are rather old and perhaps no longer appropriate. One example of this is a 15-year-old paper quoted in connection with the accuracy of satellite temperature retrievals compared with nearby radiosonde stations. Some more recent assessments could have been quoted in this context. A similar comment applies to a number of the data presentations which refer to work from the early 1970s or earlier; these are often presented as gospel with no suggestion that subsequent advances and improved techniques may have caused us to change our perception of what is the 'observed' structure of the atmosphere. In particular, our understanding of the global distribution of the moisture budget and the atmospheric meridional fluxes of energy have come a long way since then. To at least refer to this is all the more important in that the book is aimed at students.

The last chapter in the book is very short (six pages) and, I felt, out of place. It is 'less formal and more speculative' than the rest of the monograph and was intended to illustrate some of the possible uses of information in the book. I found the chapter somewhat indulgent and it left the book on a 'down' note. The author labours over what the weather on the earth would be like if the earth rotated in the opposite direction and presents some quaint and misleading observations on 'global change'. To be fair, the author does say that the reader may skip the chapter without concern but I felt if such a chapter was to be included it could have been more imaginative and informed.

There are several nice touches to the text including the incorporation at the beginning of each chapter of insightful quotes taken from papers written up to three centuries ago. There are also several reproductions of maps presented in some of the early seminal papers, including one of the tropical surface circulation published by Halley in 1686. The author has an appreciation of the historical development of the subject and this is communicated to the reader.

The broad topic of the global atmospheric circulation is presented in a pleasant and relatively new way and the monograph fits a definite need. The book is well written and it is clear that the author is comfortable with each of the topics he discusses. He has written the text primarily for beginning graduate students and for scientists who want accurate observations and simple but sound theories displayed in one book. The text can be recommended for both these groups.

Ian Simmonds

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Fundamentals of Atmospheric Energetics by Askel Wiin-Nielsen and Tsing-Chang Chen (Oxford University Press, 1993) ISBN 0-19-507127-1. $110.00.

The field of atmospheric energetics aims to elucidate the transformation mechanisms and magnitudes of energy components associated with the dynamics of the atmosphere. A. Wiin-Nielsen, of the Geophysical Institute in Copenhagen (and a former Secretary-General of the WMO), and T.-C. Chen, of Iowa State University, have made major contributions to the field over many years. As there are few textbooks on the subject suitable for advanced students of meteorology, this work is to be welcomed.

The book begins with some elementary examples introducing the basic concepts of the energetics of fluids. Several chapters follow in which the equations for the generation and conversions of kinetic energy and available potential energy in the atmosphere are derived. The energy diagram of Lorenz, which illustrates the partition of quantities into zonal and eddy components, is described. Further chapters derive the equations in baroclinic/barotropic, rotational/divergent, and spectral wave representations. Formulations for open and moving domains are given. Heat and momentum transports and enstrophy are also considered. There is a brief discussion on the theory of the cascade of energy to small scales.

This theoretical section takes 130 pages of mostly rather dry mathematics, and is fairly heavy reading. It is illustrated by examples drawn largely from the authors' studies from the 1960s and 70s, many of which used limited datasets confined to the northern mid-latitudes. I would find these chapters more satisfying, and informative, if analyses of recent global datasets were presented. For some of the methods described, e.g. the energetics of interactions between spherical harmonic components, the lack of recent references casts doubt on their usefulness.

The second half of the book presents case studies of energetics covering much of tropospheric meteorology. Two chapters describe work of various researchers on the energetics of blocking patterns, stationary eddies and quasi-periodic variations. There is an interesting discussion of the cause of subtropical jet streams. Data from both observations and model simulations of the northern hemisphere are used. Unfortunately the studies tend to be rather dated. The importance of some cases, e.g. Fourier analyses of annual cycles, is questionable. Given the didactic aims of the authors, it is notable that there is no discussion on the energetics of baroclinic instability. The focus is on conversions between potential and kinetic energies, rather than on the underlying physical phenomena.

Studies of the energetics in the tropics are then presented. One long chapter describes studies of the planetary-scale circulation, several of which are from Chen's work. Various theoretical approaches are taken. Data studied include observations from the GATE experiment and analyses of 1967 and 1979, and also simulations of the GLAS numerical model. There is much emphasis on harmonic analysis of the data, which to my mind does not necessarily lead to a clarification of some processes, for example monsoonal circulation. A second chapter presents several studies of tropical synoptic-scale waves. There is no discussion of ENSO, or tropical cyclones.

The southern hemisphere is mentioned explicitly only in the final chapter, most of which compares the circulation in the two hemispheres during 1979. A few studies of jets and vacillation of the energies are mentioned. Curiously, the presentation of data for the northern hemisphere here is often better than that of earlier chapters.

A set of exercises and answers covering basic concepts is included in the book, along with a series of problems which explores the energetics of the 2-layer model.

The book could have been improved with better editing of the chapters, and typographical errors and omissions in the text and figure captions may also frustrate the reader. However, the least appealing aspect of the book, I find, is the limited attempt to describe dynamical energetics in the context of energy exchanges through the whole climate system. Radiative, hydrological and surface processes, which are the focus of much recent atmospheric research, are idealised or ignored. The vagueness in the treatment of the 'dissipation' of kinetic energy (which is a residual in these analyses) is somewhat disturbing. In one case, that of the enstrophy budget in the tropics, dissipation emerges as one of the largest terms.

Regardless of these limitations, the book is a significant achievement and brings together a body of classical theory and research in dynamical meteorology. It should be a useful reference for students and researchers specialising in energetics.

Ian Watterson

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Atmospheric Boundary Layer Flows: Their Structure and Measurement

by J.C. Kaimal and J.J. Finnigan (Oxford University Press, 1994) ISBN 0-19-506239-6. 289 pp. $US69.95.

Chandran Kaimal has an impressive background in measuring the structure of the atmospheric boundary layer (ABL). He played a leading role in the Kansas and Minnesota field experiments and in the design and operation of the Boulder Atmospheric Observatory. John Finnigan also brings a wealth of experience in measuring atmospheric boundary-layer flow. His particular interest is in flow over and within plant canopies and over hills. Their book, *Atmospheric Boundary Layer Flows: Their Structure and Measurement*, differs from many books on the ABL in its strong emphasis on measurement and nonhomogeneous flows.

The first chapter sets the stage by describing flow over flat uniform terrain. Basic concepts such as Monin-Obukhov similarity, and convective mixed-layer, convective matching layer and stable outer layer scaling are introduced. The stability variation of similarity functions and the vertical variation of mean variables, variances and fluxes give the reader a clear picture of the boundary-layer structure. Interestingly, the authors choose to present the momentum profile stability function Ψ_m as a table rather than in closed form and they omit any discussion of the potential temperature profile stability function Ψ_h.

The second chapter continues the discussion by examining spectra and cospectra over flat uniform terrain. In addition to introducing the concepts of the inertial subranges of Kolmogorov and Corrsin, the authors carefully describe the limitations and practical aspects of using Taylor's frozen turbulence hypothesis and converting from frequency to wavenumber space. Analytical expressions for nondimensional spectra and cospectra, spectral peaks and structure functions are given which are useful in engineering applications.

Plant canopies are then introduced, complicating the flow. Within the canopy the turbulence intensities are very high and the fluxes are no longer constant with height. Spatial averaging is required. Observations of mean flow, fluxes, spectra and the terms of the energy budget are presented and the authors give a detailed discussion of why K-theory fails in this situation.

An abrupt change in surface roughness is considered in the next chapter. Field and wind-tunnel observations and theory are used to demonstrate the difference between rough to smooth and smooth to rough transitions. Abrupt changes in heat and moisture fluxes are also treated in detail, both for local advection and for longer fetches. However, as the authors emphasise, the data base of reliable experiments in the area of changing terrain is too small and this is limiting our understanding.

Chapter 5 deals with flow over hills where the controlling parameter is the Froude number. Because of the importance of the curvature and acceleration length scales, new terms are introduced into the momentum equations. Much of the mean flow discussion is based on the linear theory of Julian Hunt and his colleagues and concentrates on the near-surface (inner) layer. The turbulence of the inner layer should be in approximate equilibrium, but above this region rapid distortion takes place and the flow is not in equilibrium. Toward the end of this chapter there is a brief discussion of the buoyancy curvature analogy and how the neutral logarithmic wind profile is modified because of curvature effects.

In Chapter 6 the authors give a series of brief summaries, outlining the basic principles of *in situ* mean and turbulent measurement of velocity, temperature, humidity and trace gases and the measurement of pressure fluctuations. Advice is given on measuring the terms of the surface energy balance, employing towers and masts as instrument platforms, taking measurements in plant canopies, making measurement over sloping terrain, extending measurements above tower heights, and remotely sensing the ABL.

The last chapter discusses data acquisition and processing. The requirements for determining averaging times, sampling rates, record lengths and error levels are examined and the theory is illustrated with examples. Guidelines are also presented for preparing and processing spectral data and for data archiving.

This is a practically oriented book designed with the experimentalist in mind. It is well written and gives a valuable overview of the structure of the ABL. Its major strengths are its depth of coverage of flow over canopies, over changing terrain and over hills, and the helpful advice in experimental design and data processing. I highly recommend it and hope that it encourages researchers to pursue those areas where our knowledge is presently limited by a lack of definitive experiments.

Dale Hess

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