J. Fluid Mech. (2001), *vol.* 438, *pp.* 408–409. Printed in the United Kingdom

BOOK REVIEW

Small-Scale Processes in Geophysical Fluid Flows. By L. H. KANTHA & C. A. CLAYSON. Academic Press, 2000. pp. 888. ISBN 0124340709. $115.00.

This is a comprehensive and well-organised review of mixing and other small-scale processes that occur within and between the atmospheric and marine (and lake) environments. By small-scale processes the authors mean length scales from millimetres to a few hundred metres (possibly a few kilometres) and time scales from fractions of a second to at most a few hours. This range encompasses the turbulent mixing found in oceanic and atmospheric mixed layers, surface and internal waves, and double-diffusive processes. (There is also a volume on *Numerical Models of Oceans and Oceanic Processes* in the same series by these authors, covering larger-scale processes.)

The style of the main part of the book is that of a sequence of substantial review articles, and this is followed by a set of useful appendices. To give an idea of the scale of the book, at nearly 900 pages and with some 1200 references, the amount of material covered is approximately equal to that covered by two complete issues of, for example, *Annual Reviews of Fluid Mechanics*. While each chapter begins with an introduction to the main features of that chapter's subject, the book is not designed as a general introduction to geophysical fluid processes. It is, rather, a professional's handbook and will, I predict, prove especially useful to modellers in many fields. Whether you want to estimate salt-finger fluxes or find out the various ways people have tried to model the oceanic mixed layer, this book is a good place to start.

The opening chapter is a substantial and thorough review of turbulence and turbulence models. It begins with a description of the basic features of turbulence and its characteristic scales. The sections on modelling cover everything from the law of the wall to direct numerical simulations, via second-order closure, large-eddy simulations and renormalization group analysis.

The next two chapters deal with the oceanic mixed layer (OML) and atmospheric boundary layers (ABLs) respectively. The chapter on the OML includes details of solar penetrative heating, Langmuir circulation, convective mixing, mixing processes at different latitudes (including mixing under ice cover) and a section on bottom boundary layers. This is followed by a review of OML models, from slab models to second-order closure schemes, together with a substantial section on biological and chemical models. The chapter on ABLs includes sections on convective ABLs, nocturnal ABLs and the marine ABL. It also includes sections on flow over plant canopies, internal boundary layers, and the effects of clouds and topography. The chapter finishes with a short section on modelling ABLs.

Chapter 4 links the previous two chapters, dealing with surface exchange processes (and also includes air–land fluxes). A range of parameterization schemes are presented for heat, momentum and moisture fluxes along with a substantial collection of measured values of various transfer coefficients. There are sections on surface renewal theory and on the oceanic cool skin, with the final section dealing with satellite measurements of surface fluxes.

Still at the air–sea interface, the next chapter deals with surface waves, beginning with linear theory, then through finite-amplitude effects and wave–wave interactions to wind-wave spectra. Mechanisms for wind-wave generation, dissipation and propagation are reviewed, followed by wind-wave predictions, breaking waves and satellite measurements. Chapter 6 is a review of internal waves, concentrating on oceanic internal waves (though the theoretical sections are general). As with the surface waves, generation, dissipation and propagation mechanisms are considered, and then the Garett and Munk internal wave spectrum is reviewed. In addition there are sections on internal solitons and on the implications of internal waves for deep ocean mixing.

Chapter 7 deals with double-diffusive processes which (in contrast to mixing processes) tend to increase density contrasts and reduce potential energy and have the effect of a negative diffusion coefficient for density. This chapter includes reviews of oceanic observations, the conditions needed for various double-diffusive processes to occur and laboratory experiments. There are also sections on analytic models and flux parameterization. The final chapter covers the processes peculiar to freshwater lakes such as thermal bars and thermobaric instabilities (related to the density maximum for freshwater and its dependence on pressure). There are short case studies of Lake Nyos, Crater Lake (Oregon) and Lake Baikal.

The appendices are an important component of the book. These include the equations of state for seawater, freshwater and the atmosphere; useful lists of constants; and typical values for various geophysical quantities. There is also a substantial summary of scales and non-dimensional numbers (running from the buoyancy scale to the Wedderburn number) and finally a collection of short biographies.

Given the size of the book and the amount of material covered it is not surprising that there is the occasional minor error and typographical slip, but I found relatively few and none that seriously detract from the book as a whole. The authors have concentrated on oceanic processes but it is gratifying to find, for example, the OML and ABL reviewed side-by-side, since the time is passing when ocean modelling and atmospheric modelling can be regarded as separate disciplines. The concentration of so much information in a single volume makes this book an exceptionally useful reference for anyone working in geophysical fluid dynamics, oceanography and ocean modelling; and a useful short-cut for any students beginning their study with a survey of the existing knowledge in a field.

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