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REVIEWS

Atmosphere–Ocean Dynamics. By A. E. GILL. Academic, 1982. 662 pp. £50.00 (hb), £29.50 (pb).

Study of the motion of 'natural fluids' has come to be known as geophysical fluid dynamics. What marks this field particularly is that the oceans and atmospheres of Earth and the planets are on centre-stage; diverse methods are used to understand them, but the end is always a set of observations, and the observations are usually more dramatic than the theory that set one looking in the first place.

While it is primarily theoretical, I think that Gill's textbook is unusual in expressing adequately the balance between looking and speculating. He skilfully accompanies important dynamics with a descriptive discussion of the relevant observations. Indeed, in recent years the 'distance' between theory and observations has narrowed. Gill has exploited well the newly found strength of simple theory. An example of the kind of phenomenon under study is the famous 'el Niño' of the tropical Pacific. Events linking the tropical ocean and the global atmosphere cause droughts, deluges and dislocations of fish and bird populations across a wide swath of the Earth. In el Niño of 1982–3 it happened that extensive measurements were in progress in both ocean and atmosphere. The theoretical modelling of these events makes a remarkable and simple story, the basis of which is well treated in Gill's text.

Collections of review articles have recently shown this same vigorous duet between theory and observation. In particular *The Evolution of Physical Oceanography*, the 60th birthday volume for Henry Stommel (edited by Warren and Wunsch, MIT Press, 1982) contains reviews, in a pedagogical spirit, of ocean dynamics and *Large-scale Dynamical Processes in the Atmosphere* (edited by Hoskins and Pearce, Academic Press, 1983) does the same for atmospheric general circulation. These three volumes are examples of the remarkable level of understanding of planetary flows reached when adequate observations are seen in the light of careful dynamical theory.

Gill's book is centred upon the rapid response of the oceans and atmosphere, with great emphasis on gravity waves and the shorter-period members of the large class of phenomena which depend on Coriolis forces. It is with just these phenomena, in the strong oceanic waveguides provided by the thermocline, the equatorial zone, and the coastal regions, that linear analysis is particularly close to the truth. At middle and high latitudes the large-scale motions in mid-ocean lack such waveguides, and obey more nonlinear basic dynamics. These are given abbreviated treatment here. The general circulation enters where it fits the pattern of 'quick response'. Rossby wave dynamics is given most attention in the equatorial case, where the energy-containing waves have large phase speed, hence tending to be linear.

Basic principles occupy much of the first half of this 600-page work. There is a brief introduction to the effects that drive the oceans and atmosphere: radiation, drag at the base of the atmosphere, and the transfer of heat and moisture between sea and air. Some of the best available maps of the data are shown as illustrations, although one must still be wary that the data are not all very good, particularly with subtle quantities like rainfall. We look to clever use of orbiting satellites for improving the situation. There is a useful introduction to the respective properties of atmospheres, moist and dry, and oceans, with their complicated equation of state. The great range of scales (10 decades) between the planetary scale and that of molecular dissipation

provides the fundamental difficulty of the subject, and this is well brought out. Basic thermodynamics, hydrostatics, and fluid dynamics are treated, for oceans and atmospheres in parallel.

About 200 succeeding pages are devoted to adjustment under gravity. External and internal waves are treated with careful analysis and lively use of historical quotations, from Marsigli to Benjamin Franklin. The development is closely tied to, and illustrated by, geophysical problems. This makes the more extensive mathematical treatments of Whitham (*Linear and Nonlinear waves*, Wiley, 1974) and Lighthill (*Waves in Fluids*, Cambrige, 1978) entirely complementary.

Planetary rotation is introduced in a clear and general way. The contrasting treatment of gravitational adjustment of a step-like initial sea-surface elevation, with and without rotation, is a marvellously rich example. One rejoices at seeing Reid's careful dynamic-height maps of the oceanic general circulation used to illustrate geostrophic balance, rather than the tired cartoons of the depth-averaged flow, or surface flow, that are found in many prior texts. Potential vorticity is carefully derived (although Rossby's early contributions are neglected in favour of Ertel). Ekman layers are discussed. With this ammunition we proceed to look at the equatorial and coastal waveguides. In both regions a theory of adjustment comes close to representing also a theory of the circulation, at least in its mechanical aspect. The Sverdrup relation enters the comprehensive story of tropical dynamics, as a relatively minor player.

Mid-latitude dynamics occupies the final 100 pages, with a brief but clear account of classical ocean-circulation theory. It is unfortunate that some of the fascinating hydrographic sections cutting through the wind-driven gyres and thermohaline arteries were not used as illustrations here. It is also unfortunate, but most understandable, that there is not space to address challenging questions about formation of water masses or air masses, the complex buoyancy dynamics of an icy, salty ocean, the creation of the basic stratification, or interior modes of the general circulation. 'Eddies in the ocean' are given a scant two pages. The ventilation of the interior ocean from its boundaries, and the general problem of 'Lagrangian' tracers are also absent. Two important techniques might well have been given more mention; first, the use of numerical models in company with theory and, secondly, the detailed testing of dynamical ideas with modern observations (for example, Bryden's study of baroclinic instability in the Southern Ocean using moored instrumentation). Finally, one must feel a little disappointed that the interactively coupled nature of the atmosphere and oceans cannot play any part in a text that discusses each of them so intimately: the research is only now getting under way.

Discussion of the mid-latitude atmospheric circulation once again emphasizes wave propagation (at the expense of nonlinear phenomena like the enstrophy cascade). The synoptic quasi-geostrophic equations, vertical propagation in the atmosphere, and wave drag on mountains find a place here. There is also a lucid introduction to baroclinic instability and frontogenesis.

Gill has taken on the formidable task of organizing a vast field by selecting those linear phenomena that really have predictive power. It is not surprising that the result gives the reader occasionally a sort of spectral jet-lag, jumping for example between hurricane models, hurricane-forced waves, Ekman layers, the planetary Hadley cells, seiches in gulfs and global tides in the space of 50 pages.

Its is easy to call attention to such problems, but I cannot see a way to make an account of this rich and varied subject that is better organized or more teachable. This is a finely crafted book, and it will be a lasting contribution to our field.

P. B. Rhines

SHORTER NOTICES

Proceedings of the Fifth GAMM Conference on Numerical Methods in Fluid Mechanics. Edited by M. PANDOLFI AND R. PIVA. Vieweg (Wiesbaden), 1984. 390 pp. DM78.00.

Although this conference had no particular theme within computational fluid dynamics (CFD), nearly all the papers are concerned with laminar flow, with only 5 of the 48 devoted specifically to turbulent flows. There is a wide variety of problems and methods, and standards of presentation. Many of the papers present results from (variations of) established techniques rather than investigating new numerical methods.

Transonic flow past an airfoil (using either the Euler or the potential equations) is the most popular problem with approximately a quarter of the papers. This problem is tackled using, for example, finite-volume, -element, and -difference schemes, and pseudo-spectral, predictor–corrector, Newton iteration, and multi-grid techniques. Other problems studied include gas mixtures, boundary layers (four papers each), shallow water flow, and convection (one paper each).

This volume does highlight the increasing importance of pseudo-spectral and multigrid techniques in CFD. However, its diversity means that only a fraction of the contributions are likely to be of interest to any particular worker in the field.

Cavitation. Mech. Engng Publ. Ltd (Bury St Edmunds), 1983. 298 pp. £38.00 (£49.50 overseas), paperback.

This volume contains the 35 papers presented at the Second International Conference on Cavitation in September 1983, sponsored by the Institution of Mechanical Engineers and the American Society of Mechanical Engineers. The last equivalent conference on the subject was held in 1974.

The papers include contributions on bubble dynamics, erosion of surfaces in centrifugal pumps, cavitation in jet pumps, centrifugal pumps, cascades, control valves, journal bearings, hydrofoils and propellers. There are also papers on noise phenomena associated with cavitation. It is noted, with approval, that the papers carry substantial lists of references to work carried out in the last decade. The publication therefore represents a most useful summary of the state of knowledge on cavitation at 1983. It would form a convenient starting point for anyone beginning research in the field or a most useful updating for those already engaged in such work.

Foundations of the Probabilistic Mechanics of Discrete Media. By D. R. AXELRAD. Pergamon, 1984. 166 pp. £15.00.

As the blurb on the back cover says, 'this book discusses the application of modern functional analysis to the probabilistic mechanics of structured media'. The emphasis is on general results, and the arguments are axiomatic in character. There are chapters on the mechanics of solids and fluids with random discrete micro-structure but real problems of fluid mechanics are not touched.

Atmospheric Dispersion in Heavy Gases and Small Particles. Edited by G. OOMS AND H. TENNEKES. Springer, 1984. 440 pp. DM98.00.

Over the past 15 years there have been a number of large-scale field experiments and associated laboratory and theoretical investigations on the dispersion of dense gases in the atmosphere, in order to understand and predict what may happen when such gases are released accidentally. (There have been a number of accidents to make the threat credible.) Many of the leading research workers in the field gave papers at a IUTAM Symposium in Scheveningen, Netherlands, in 1983. This volume contains the proceedings, which are copies of the contributors' typewritten papers submitted *after* the conference; it gives a useful overview of research in the field, details of some of the recent field experiments, and indications of new ideas about the dispersion processes. However the results of the largest experiment at Thorney Island in England (1982–4) were not available soon enough to have been analysed by 1983. (These are to be published in *J. Hazardous Materials* in 1985.) There were only two (but interesting) papers on the dispersion of particles.

Gas Transfer at Water Surface. Edited by W. BRUTSAERT AND G. H. JIRKA. Reidel, 1984. 639 pp. Dfl 210.00/$78.00.

The transfer across the surface of environmental waters governs the transition between the dissolved state in the water of numerous substances and their gaseous state in the atmosphere, and is often a critical phase in the natural cycle of these substances, or in their industrial processing. A conference was held at Cornell University (NY) in June 1983 to concentrate just on this transfer process; 7 review lectures and 52 contributed papers were given, chiefly by fluid mechanics specialists, environmental engineers, chemists and geophysicists. The lectures and papers are in 7 groups: (1) physico-chemical fundamentals; (2) turbulence near gas–liquid interfaces; (3) interfacial motions and instabilities; (4) conceptual models and parametrization of gas transfer; (5) field and laboratory experimental techniques; (6) climate and oceanographic applications; (7) water quality and engineering applications. Since there is no other recent book on this topic and since this has been well produced, many readers of *JFM* interested in gas transfer across gas–liquid interfaces will want to read and refer to this volume.