Book reviews

Weather Satellites: Systems, Data and Environmental Applications edited by K. Rao, S.J. Holmes, R.K. Anderson, J.S. Winston and P.E. Lehr (American Meteorological Society, Boston, 1990) ISBN 0 933876 66 1. 502 pp., US$80.00.

Meteorology was one of the first of the environmental sciences to recognise the potential of satellite observations of the earth and its atmosphere and to benefit from the routine incorporation of satellite data into prognostic analysis and climatic research. It is now thirty years since the launch of the first meteorological satellite TIROS-1 in April 1960.

This volume presents a history of applied satellite meteorology and an overview of current-day applications. While concentrating on meteorological remote sensing, the latter chapters of the book describe the uses of data acquired from meteorological satellites for land surface analysis. Ocean surface remote sensing applications are not discussed but will be presented in a separate volume.

This book of 502 pages is divided into eleven major sections with each section containing three or four chapters. Perusal of the acknowledgements shows there were 116 contributors to the volume. The five editors headed by Dr. Krishna Rao, who is Director of NOAA Office of Research and Applications, National Environmental Satellite Data and Information Service, have done a good job of editing contributions and presenting the text. The format and style for each chapter are standardised and overall the text reads well, with few of the problems encountered in some of the other pot-pourri offerings on remote sensing, where authors contribute individual chapters with little obvious collaboration or commonality of purpose. The book is well-illustrated and contains a smattering of coloured illustrations.

The first two sections provide an introduction to satellites and meteorology, and a short history of civilian weather satellites including both those in a sun-synchronous polar orbit and those in a geostationary orbit. Included is a short introduction to the principles of remote sensing as they relate to the detection, capture and measurement of electromagnetic energy, and how reflectance and emission spectra of targets can be used to identify and gain information about those targets.

Section 3 describes the characteristics of weather satellite programs operated by the United States, the Soviet Union, ESA, Japan and India and the mechanisms for the coordination and dissemination of data. This is followed by a detailed description, in Sections 4 and 5, of individual sensors and the instrumentation required for satellite command and data reception.

Data processing and distribution are important elements of any satellite program. The volume of data generated in a day from US polar and geostationary satellites is in the order of 10^{11} bits. This has to be received, stored and processed into actual geophysical measurements before being distributed to users and archived for future use. Current procedures for the actual processing, measurement and distribution of meteorological satellite data are described in Section 6.

The second half of this book deals with the applications of meteorological satellite data. Early imagery from weather satellites showed they could be used immediately for weather analysis and qualitative interpretation. Global coverage enabled meteorologists to observe synoptic-scale features. In recent years, better instrumentation and interrogative methodologies have led to the derivation of selected meteorological parameters, together with synoptic and convective-scale weather analysis and forecasting and various applications related to aviation, marine science and land surface analysis.

Section 7 describes basic image processing and interpretation techniques; outlines the components of image display and analysis systems; discusses methods of determining cloud heights and cloud-wind motion patterns from satellite imagery before dealing with atmospheric readings, precipitation estimation, tropical cyclone analysis, and synoptic and convective-scale weather analysis and forecasting. An overview of aviation applications is also presented with emphasis on the provision of specialised information on terminal cloudiness, fog, storms, winds and turbulence, and atmospheric aerosols.

In Section 8, entitled 'Applications of Satellite Data to Land and Ocean Sciences', some of the spin-offs occurring from meteorological satellites to other areas of the environmental sciences are outlined. These include the determination of land, sea and lake surface temperatures, the detection of fires, volcanic activity and heat islands, and the mapping and analysis of snow cover.

Section 9 examines the use of satellite data for making inferences related to the climatic aspects

of clouds, aerosols, ozone and their influence on the radiation budget of the atmosphere as well as their contribution to the real-time monitoring of the earth's climate.

Methods of assessing and mapping the condition of vegetation resources on the earth's surface using the NOAA AVHRR sensor are described in Section 10.

In summary, this volume provides a comprehensive overview of meteorological satellite remote sensing and very adequately demonstrates the degree to which modern meteorology is dependent on space-borne satellite data acquisition. It provides sufficient background information to allow the uninitiated to appreciate and understand both the technology of data acquisition and the scientific applications of remote sensing. A major strength of the book lies in the fact that it is not restricted to describing atmospheric applications but explores the usefulness of meteorological satellites for investigating the important boundary conditions that exist between the air, land and water resources of the planet earth.

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Descriptive Physical Oceanography: An Introduction by George L. Pickard and William J. Emery (Pergamon Press, 1990. Fifth edition). Hard cover ISBN 008 0379532. Stg£30.00. Soft cover ISBN 008 0379524. Stg£11.95.

This is the fifth edition of Pickard and Emery's classic text on descriptive physical oceanography. Since the publication of the first edition, in 1964, the book has served as an excellent introduction to the descriptive side of physical oceanography for students new to the field. The fifth edition has been extensively revised to reflect the rapid developments in the field that have occurred over the last decade.

The volume is divided into nine chapters. The Introduction provides a brief history of physical oceanography and an overview of the major topics of concern to oceanographers. Chapter 2 describes the topography and dimensions of the ocean basins and how they affect the ocean circulation. The physical properties of sea water and the vocabulary used by physical oceanographers are introduced in Chapter 3. The introductory material is completed in Chapter 4, which discusses the general character of the distributions of temperature, salinity and density in the sea.

Conservation of volume, heat and salt is introduced in Chapter 5, and some examples of volume and salt budget calculations are given. The majority of the chapter focuses on the individual terms in the oceanic heat budget, including a discussion of the physical factors on which they depend, their magnitudes and their geographical distributions.

Chapter 6 is devoted to 'Instruments and Methods.' This chapter has been substantially revised since the earlier editions to reflect recent advances in oceanographic technology. In particular, there is now a discussion of a variety of satellite measurements, the use of oceanic tracers, and acoustic techniques. The discussion of more traditional water-sampling methods and current measuring instruments has also been updated. The discussion of 'Methods' includes the analysis of property-property diagrams, isentropic analysis and a brief discussion of the geostrophic method.

The main focus of the book is found in Chapter 7, 'Circulation and Water Masses of the Oceans'. Following a brief discussion of the thermohaline and wind-driven circulations, the chapter presents a discussion of the general circulation and water masses of each of the major oceans in turn, including the important marginal seas. A particularly valuable aspect of the book is the collection of a concise description of each ocean in one volume, so that the character of the ocean circulation in different regions can be easily compared and contrasted. The chapter now includes a fuller treatment of sea-ice, the equatorial circulation system, and the ENSO phenomenon than was found in the fourth edition.

The volume concludes with a brief chapter on coastal oceanography and some suggestions for future work. The Appendix contains a useful summary of units commonly used in oceanography. The Bibliography includes a list of suggestions for further reading and a comprehensive list of references (updated for this volume), both of which should prove extremely useful for students interested in pursuing the topics introduced here in further detail. The technical production is excellent throughout, including many clear and informative figures. In addition, at £11.95 for the soft cover edition, the book is a true bargain.

The authors have done a fine job of targeting the material to the undergraduate or early graduate student level: the presentation is reasonably complete without overwhelming the uninitiated. However, the division of physical oceanography into separate descriptive and dynamical parts is, as the authors point out, an artificial one, and it is perhaps inevitable for the reader to occasionally wish for a fuller discussion of the dynamics responsible for the distributions described. Luckily,

Pond and Pickard have treated the dynamical aspects of physical oceanography in an equally accessible and lucidly presented work entitled *Introductory Dynamical Oceanography*. The two together provide an ideal introduction to the field of physical oceanography.

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Extratropical Cyclones — The Erik Palmén Memorial Volume edited by C. Newton and E.O. Holopainen. (American Meteorological Society, Boston, 1990) ISBN 1 878220 02 0. 272pp., US$60.00

This volume consists of written versions of the twelve invited papers presented at the Palmén Memorial Symposium on Extratropical Cyclones, jointly organised by the Geophysical Society of Finland and the American Meteorological Society, and held at the University of Helsinki, Finland, from 29 August to 2 September 1988. The motivation for holding the symposium in Finland during the last week of August was that 31 August 1988 would have been Professor Erik Palmén's 90th birthday. To quote from the preface to this volume, 'The objective of the symposium was to give, on the basis of recent observational and modelling studies, a state-of-the-art picture of research on the structure and dynamics of extratropical cyclones, a topic which Palmén pioneered during the era of advances in aerological analysis.' An implicit objective of the symposium and this volume was also to honour Erik Palmén for his significant contributions to the advancement of meteorology, particularly in the areas of large-scale atmospheric circulation systems, extratropical cyclones and frontal circulation.

As I was a participant at this symposium (perhaps the only one from the southern hemisphere), I must comment that, although the symposium was very interesting and the invited papers generally well presented, this volume is much more than just a collection of the texts of the invited talks. The papers in this volume are all improvements over the talks, being more coherent and complete and having been carefully edited so they fit together very well. The volume is well presented, with excellent illustrations and few typographical errors. As well as the high production quality, the scientific standard of the papers is uniformly high. Together, they provide excellent reviews of observational and modelling studies of most aspects of extratropical cyclones.

The first three chapters, by C.W. Newton, H. Riehl and R.J. Reed, are historical reviews of Erik Palmén's contributions to the development in understanding of extratropical cyclones, their role in the general circulation and subsequent advances over the past quarter century. The following chapters are all modern reviews of different aspects of extratropical cyclones. These include primarily observational studies (E.O. Holopainen on the role of cyclones in the general circulation and K.A. Browning on the organisation of clouds and precipitation in extratropical cyclones), theoretical reviews (B.J. Hoskins on baroclinic cyclogenesis, S. Tibaldi, A. Buzzi and A. Speranza on orographic cyclogenesis and A. Eliassen on transverse circulations in frontal zones), as well as combined observation and modelling studies (L.W. Uccellini on processes contributing to rapid cyclogenesis and M.A. Shapiro and D.A. Keyser on upper level fronts and jet streams). The last two chapters concentrate on numerical weather prediction of extratropical cyclones, with reviews of global modelling capabilities by L. Bengtsson and limited-area modelling by R.A. Anthes. Many of the authors have related aspects of modern research to the earlier work of Erik Palmén. One of the most interesting of these is the application of a limited-area fine-mesh model by R.A. Anthes to study the metamorphosis of hurricane *Hazel* to an extratropical cyclone over the east coast of the United States in October 1954. This severe storm had been the subject of detailed diagnostic analysis by Erik Palmén and all his major conclusions were confirmed by this modern modelling study.

This book is an outstanding review of knowledge of extratropical cyclones. It should be an essential part of any meteorological library, being of interest to researchers in dynamical and synoptic meteorology as well as numerical modelling and weather forecasting. It could even be used as a textbook for graduate-level courses on observations, theory and modelling of extratropical cyclones. I think that there is only one shortfall of this book; its almost complete neglect of extratropical cyclones in the southern hemisphere. They receive a brief mention in the observational review by E.O. Holopainen but any further discussion of similarities or differences in the structure or behaviour of extratropical cyclones between the two hemispheres is omitted. This bias is not surprising and, perhaps, not too important, but it detracts from an otherwise excellent volume.

David Karoly

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Climatic Atlas of the Indian Ocean Part III. Upper-Ocean Structure by Stefan Hastenrath and Lawrence L. Greischar (The University of Wisconsin Press, 1990) ISBN 0 299 12154 2. Pp. xxvi plus 247 charts and 5 tables, US$40.00.

This atlas follows on from two others, *Climatic Atlas of the Indian Ocean*, Parts I and II, by S. Hastenrath and P.J. Lamb (1979). Part I described the surface climate and atmospheric circulation in the Indian Ocean between 30°N and 30°S, while Part II dealt with the four components of the surface heat flux, all on the basis of about 4.5 million ship observations collected between 1911 and 1970. These heat flux estimates are based on four algorithms relating the components of the heat flux to wind speed, cloud amount, air and sea temperature, and relative humidity. Different choices of algorithms can result in differences of as much as 50 watts/m^2 in the net heat flux; however, the qualitative pattern of heat fluxes obtained by Hastenrath and Lamb is similar to that found by others, and contains more spatial resolution than other authors. For more details see the review in *Aust. Met. Mag., 29*, 197–201.

The new atlas seeks to complement Parts I and II by examining hydrographic data on the temperature and salinity fields of the ocean, and using them to obtain heat storage and export. Many of its charts are therefore basically updates of those found in the older atlases of Wyrtki (*Oceanographic Atlas of the International Indian Ocean Expedition*, National Science Foundation, 1971) and Colborn (Thermal structure of the Indian Ocean, *IIOE Oceanographic Monographs No. 2*, University of Hawaii Press, 1975). However, Hastenrath and Greischar note that they worked from a data bank an order of magnitude larger than was available to Wyrtki and Colborn; as a result they are able to show monthly mean maps of temperature at 50, 100, 150, 200, 300 and 400 m, as well as at the surface. Wyrtki only showed annual mean maps. Some interesting features emerge — e.g. there is clearly a seasonal cycle in temperature down to 300 m (though not at 400 m). A disappointing feature of the new atlas is that it does not show the annual means of these patterns for comparison with Wyrtki's atlas or the much-used Climatological Atlas of the World Ocean (*NOAA Professional Paper No. 13*, S. Levitus, 1982). The contour interval of only 2°C is also rather coarse for use in, for example, estimating vertical temperature gradients.

Six-monthly maps of salinity (November-April; May-October) cover the northern winter and summer monsoon at 0, 100 and 300 m. The most striking feature is how small the seasonal differences are, even at the surface in the Bay of Bengal and the northern Arabian Sea — regions that are subject to strong monsoonal differences in the net freshwater influx.

Monthly maps of mixed-layer depth and thermocline thickness match those of Colborn (1975), but are based on substantially more data. Similarly, maps of geopotential anomaly of the surface relative to 400 decibars match those of Wyrtki (1971), but the new maps show features like the Leeuwin and Somali Current much more clearly than Wyrtki's maps.

Hastenrath and Greischar return to their theme of heat flux studies by showing monthly mean charts of heat storage in the top 400 m (obtained by taking the difference in heat content between the month after and the month before, divided by the two-month time difference). They also estimate 'heat import' by adding the net heat flux into the ocean (from their Part II) to the heat storage. (They actually display the negative of this quantity, i.e. 'heat export'.) In fact, at any given location the heat storage dominates over the net heat flux by a factor of about 10, so that the 'heat export' maps are close to being the negative of the heat storage maps; the reason for this behaviour is that the seasonal reversal of monsoon winds results in major shifts of upper-ocean water, through Ekman pumping.

Data density varies spatially by more than two orders of magnitude in the Indian Ocean, and it may also vary seasonally. One defect of the atlas is that it gives little indication of the data density map for a given chart: many contours end in the middle of the chart, presumably because data density was too low, but many maps have a confusing appearance as a result. Annual mean maps of data density are given, but some monthly mean maps are left blank in certain areas while those for the next month may contain contours: the reader has to guess whether the difference reflects a flat field, or absence of data, in the month where a blank field is shown.

Libraries should obtain a copy of this volume; it is a useful browse. However, in these days of easy access to computer data bases, it seems unlikely that this atlas will be as heavily thumbed through as those of Wyrtki or Levitus.

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