

Book Reviews

Meso-scale Atmospheric Circulations
by B. W. Atkinson.
(Academic Press 1981) £32.40.
Hardbound. 495 pages.

Prof. C. H. B. Priestley in his scientific lecture to the 1982 WMO Commission for Atmospheric Sciences Session in Melbourne, expressed a view that the meso-scale in atmospheric behaviour had not been receiving the resources or experiencing the expansion of knowledge seen in the the planetary and micro-scales. This book is likely to form part of the process of redressing the balance.

The book fills a requirement for an up-to-date review of a range of tropospheric phenomena from the sea-breeze to katabatic winds. There have been previous reviews on most of these topics but as they have been mainly in university theses they are not as accessible as this book and not as comprehensive over the range of phenomena.

The first chapter presents a discussion of what is meant by 'meso-scale' with a chronologically listed ranged of ideas and definitions from the literature. It appears that the term is easier to discuss than to define. Different authors have their own ideas of what should be included in meso-scale and no doubt readers will also have opinions as to what this book should or should not cover.

The chapters are arranged under the two broad headings of topographically induced and free-atmosphere circulations to highlight the main feature of the individual phenomenon. Within each chapter the material is subdivided into a descriptive introduction, observations, theory and a review of experiments in laboratory simulation.

Lee waves are treated in chapter two presenting the results of the major studies. The treatment is an historical one. The hypotheses advanced by early workers are presented and sometimes shown to be invalid by later investigations. Chapter three on downslope winds presents a very useful review of that generic category usually described as foehn winds. It is only recently that meteorologists have come to properly understand foehn winds, as for too long they considered them in terms of the changes in surface temperature and surface relative humidity.

Chapter four is a short chapter on circulations and wakes and is followed by the longest chapter which is on the sea/land breeze circulation. The sea-breeze has an extensive literature and the chapter presents a useful summary. There are some Australian studies which are not included indicating presumably that a selection has had to be made from the extensive literature. Chapter six covers slope and valley wind circulations and includes some discussion on Antarctic katabatic winds.

The last section of the book contains four

chapters under the heading of 'Free Atmosphere Circulations'. Moving gravity waves (chapter 7) presents a review of gravity waves as observed by surface microbarograph records, radar and satellite cloud photographs. Severe local storms (chapter 8) have been extensively investigated and the chapter presents a comprehensive review of work up to 1978. Chapter 9 is a concise review of cloud streets and open-and-closed cellular cloud patterns.

The final chapter on 'Circulations in Cyclones' is 'concerned with the nature, mechanism and interrelationships of large and small meso-scale circulations in cyclones and their interaction with synoptic scale flow'. This is a subject on which the author has published papers, in particular on the validity and results of studies on surface precipitation pattern movements as an indication of the life of circulation systems. The observational review is comprehensive with respect to those impressive studies by Harrold and Browning on extra-tropical fronts and the US studies of tropical cyclone rain bands. Numerical models apparently have yet to capture exactly the various scales of interaction to model circulations in cyclones.

The book should encourage studies in meso-scale atmospheric phenomena by pointing out the strengths and weaknesses of our current knowledge. It will make some recent results more accessible particularly for foehn winds and indicate the wide variety of simple models which are required to adequately model the phenomenon observed at different locations. The publishers state that the book 'will prove essential reading for all academic and professional meteorologists'. This is a reasonable view, although its historical review format, having discussions of conflicting hypotheses, makes it longer and possibly confusing for a student audience.

S. C. Allen

The CO₂-Climate Connection: A Global problem from an Australian Perspective by G. B. Tucker,
Australian Academy of Science,
Canberra, 1981.
(ISBN 0 85847 100 0)

Over future decades a significant global warming may occur as the result of man's ever-increasing use of fossil fuels and the consequent continual increase in atmospheric carbon dioxide concentration. The global mean surface temperature increase due to a doubling of CO₂ is expected to be some 2 to 3°C. Such a temperature change would be a major climate perturbation. It is larger than any which has

occurred over the past 10 000 years, and is approximately half the magnitude of the temperature change between the last glacial maximum and today. As man's greatest scientific experiment, albeit uncontrolled, it is one which warrants and is receiving serious attention.

The CO₂ question (and Tucker's book) is divided conveniently into three interlinked subject areas: prediction of future atmospheric CO₂ increases; prediction of the climatic effects of these increases; and estimation of the impacts of both of these changes on the natural biota, agriculture and society.

Future CO₂ increases depend on the sources and sinks of CO₂ and on how these are redistributed between the carbon reservoirs of the atmosphere, the oceans and the biota. The main source of CO₂ is fossil fuel consumption. As far as the atmosphere is concerned the ocean acts as a sink for some 40 per cent of the input, while the biota may act as a source or a sink. The biota, specifically the earth's forests, have almost certainly been a source of CO₂ over the past century or so, but whether they are currently a source or a sink is a debatable point.

These credits, debits and exchanges are the substance of carbon-cycle models which may be used, in conjunction with projected inputs of CO₂ over future decades, to predict future atmospheric CO₂ levels. Tucker describes recent carbon-cycle modelling work in Australia, but fails to put this into a proper context — no other carbon-cycle modelling work is described. This is unfortunate since some of the results quoted differ substantially from other model estimates. For example, the projected CO₂ level in 2025 is given as approximately 520 to 600 ppmv, depending on how much of future energy demand is supplied by fossil fuels. The energy requirement assumed for this scenario, 33TW by 2020, is considerably higher than other recent estimates. This figure corresponds to a 3 per cent annual growth rate, compared with a more generally accepted value of around 2 per cent which would lead to 'only' 20TW energy use in 2020 and a correspondingly lower CO₂ level, near 450 ppmv. All of these estimates are, of course, subject to considerable uncertainty. The basis of the lower projected energy growth rate is the recent decline in this parameter. Although Tucker shows Rotty's much-reproduced data on fossil fuel CO₂ releases since 1860, he does not point out the rather dramatic drop in the annual rate of increase which occurred around 1973 after the oil 'crisis'.

While future CO₂ levels are uncertain, it is likely that, no matter what energy strategy evolves, 450 ppmv will be exceeded early in the 21st century. A doubling of the pre-industrial level (260–290 ppmv) is highly probable. Thus, a doubling of CO₂ is taken as the standard case for CO₂–climate experiments. Tucker's review of climate model results is well balanced and comprehensive. He stresses the

uncertainties, especially with regard to feedback processes involving clouds and the extremely simplified way the oceans are modelled. His opinion is that current estimates of the magnitude of CO₂ warming are probably too high. This opinion is based largely on a qualitative evaluation of model simplifications: but as Tucker himself says (p. 28) '... qualitative arguments are liable to be specious because of the sheer complexity of the problem and the multiplicity of interactive and feedback mechanisms involved'. The possibility that a significant additional warming may occur due to the increasing anthropogenic input of other radiatively active trace gases is not mentioned.

The consequences of CO₂–induced climatic change will depend on the regional details, details which we cannot yet determine. Very few models with realistic geography have been applied to the CO₂ problem and geographical realism is an essential prerequisite for producing information at the regional scale. Recent work has indicated that the regional details in an equilibrium CO₂–climate modelling experiment (i.e. the equilibrium response to a step function change in CO₂) may differ significantly from those of a transient response experiment (i.e. the time-dependent response to a realistic time-dependent increase in CO₂). One of the most important aspects of these results is that these differences are greatest in the southern hemisphere. Transient response experiments are therefore of considerable importance to Australia, but a realistic transient response experiment with a general circulation model (GCM) seems to be many years away. Nevertheless, current GCM results do provide useful scenarios for a future warmer world and these results, together with scenarios developed using other approaches, can be used to obtain insight into the consequences of increasing CO₂.

The fourth chapter of 'The CO₂–Climate Connection' considers the consequences for agriculture, the oceans and cryosphere, energy production, and society in general. The most dramatic effect is the possible disintegration of the West Antarctic ice sheet which would raise global mean sea level by 5 to 6 m. Although this is only a remote possibility, it is thought by some scientists to have occurred naturally during the Eemian, about 120 000 years ago, when sea level was higher than today. It warrants further study. The impact on agriculture is more immediate and of considerable importance to Australia. The effects on plant life are, for C-3 plants like wheat, barley, rice, cotton, etc., both direct, through enhanced photosynthesis and attendant increase in the efficiency of water use, and indirect, through changes in climate. Just how a CO₂-induced climate change would affect agriculture will depend on the regional and seasonal details of changes in precipitation and temperature, and only educated guesses of these changes can be made at present. Furthermore, crop–climate links

are, in general, poorly understood and the effect of increasing CO₂ on pests and disease and their secondary impact on agriculture is unknown. In spite of these uncertainties, Tucker concludes quite reasonably that the overall effects could be beneficial to the total agricultural productive capacity of Australia. The possibility that some places, like Australia, might gain from increasing CO₂ while others might lose (it has been suggested that parts of the main US and Eurasian grain belts might suffer more frequent drought in a high-CO₂ world) was first pointed out years ago; but it remains a potential handicap to international cooperation on the CO₂ problem.

In spite of the general interest in and scientific concern about the CO₂ problem, there have been few concise overviews of the subject. Tucker's book sets out to review the state of knowledge (as of 1981), but to do so with an Australian perspective. Although the somewhat parochial treatment is annoying at times, the book does achieve a balance between a general review and a specifically Australian viewpoint. It is well written, in a style that is both authoritative and easy to read. It is concise (less than 50 pages of text), but has sufficient detail to give some depth of understanding, and it covers practically all aspects of the subject. Although the focus is definitely on Australian research, resting heavily on the papers published in the Academy's book *Carbon Dioxide and Climate: Australian Research* (edited by G. I. Pearman), the wider context is almost always described. The result is a review which deserves a wide, international audience, and which I can recommend wholeheartedly.

T. M. L. Wigley

The Use of Satellite Data in Rainfall Monitoring by E. C. Barrett and D. W. Martin. (Academic Press, 1981) £27.80. 340 pages.

The subject of this book may appear quite narrow and specialised to some, but a little reflection should transform that attitude by the realisation that rainfall monitoring must rank as a task of greatest importance to the needs of mankind. It is forecast that in the near future, the availability of water will supersede the present concern for oil supplies as an issue in international trade and development. The traditional means of rainfall monitoring, i.e., the rain gauge, has been inadequate for a long time, particularly in underdeveloped countries, vast and arid zones and other difficult or inaccessible areas. The only promising general remedy is the use of satellite-borne remote sensing methods.

This book aims to 'summarise present methods designed to augment conventional rainfall data using satellites to provide information on rainfall; to

denote primary uses of such methods; and to examine the prospects for obtaining still further improved rainfall data. . . . In my opinion, it is quite successful with these aims, particularly with the first two, because it is a logically structured and well-connected book, written in a style which informs and interests the reader in a very rapidly developing field without intimidating and frustrating him with jargon. It is in four parts:

- I Monitoring Rainfall: the nature of the problem;
- II Satellite Rainfall Monitoring Methods;
- III Satellite Rainfall Monitoring Applications; and
- IV Future Prospects and Possibilities.

The first third of the book describes the rainfall estimation work reported in the literature such as cloud-indexing, life history and bi-spectral methods (visible and infrared data). Then follows a chapter on the properties of microwave radiation in the atmosphere, before a chapter on passive microwave methods of rain detection. The book then turns to monitoring applications, such as the construction of rain maps over the oceans as well as over the continents, for climatic and diagnostic applications. Other applications are in monitoring of intense local falls for flash-flood forecasting, in monitoring drought and in assessing vegetation and predicting crop growth. Finally, after a brief but useful review of radar rainfall physics, the book's last thirty pages consider the feasibility of satellite-borne weather radars and a summary of present programs for monitoring with suggestions and recommendations for future work.

The book is fairly self contained and does not require prior knowledge of the subjects at an advanced level. It contains background chapters on satellite systems, radiation and clouds, properties of microwaves and radar, and a bibliography of well over 300 references up to 1979. However, I would prefer a greater emphasis, perhaps a separate chapter, on the problems of verifying satellite rain estimates by comparing them to isohyetal analyses based on gauge data, or radar echo displays. Since these data pertain to essentially different parts of the rainfall process, substantial assumptions are required for intercomparisons to be made. This book only reflects the insufficient consideration given to these problems in the published research.

The quality of the production and presentation is excellent, with figures often clearer than in the originally published papers. It is a first in this field of applied meteorology and, as such, is valuable to the expert and also most useful to the advanced student.

R. Del Beato

Corrigenda:

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In Table 1 (page 91) of the article 'The role of background observations of atmospheric composition at Cape Grim' by G. I. Pearman, the 'I's should read 'l's — for example, Trichlorofluoromethane CCl_3F , etc.

In Fig. 1 (page 59) of the article 'Current status and future prospects for numerical weather prediction — an Australian perspective' by D. J. Gauntlett and L. M. Leslie, the source of the figure was inadvertently omitted. This figure was in fact based on the TOVS retrieval system developed for Australian use in Kelly, G. A., Forgan, B. W., Powers, P., Le Marshall, J. F. R., Hassett, M. and O'Connor, B. 1982. A satellite based operational system for upper air analysis. Accepted for publication in *Remote Sensing of Environment*, Elsevier, New York.