

Book reviews

Light Scattering in Inhomogeneous Atmospheres by E.G. Yanovitskij (Springer, 1997). ISBN 3-540-61362-5, DM 128.

The foundations of the theory of radiative transfer were laid down in classic texts by S. Chandrasekhar (1950), V. V. Sobolev (1975) and H. C. van de Hulst (1957). These texts examined the underlying physical principles and developed approximate solutions of the transfer equations, generally for media whose optical properties were independent of position. This text by Yanovitskij extends the earlier analytical results to layered media in which the optical properties may vary with depth but not with the horizontal coordinates.

The book is divided into three sections. The first reviews basic concepts and the analysis of radiation in homogeneous atmospheres. It begins with the idealised case of an atmosphere with infinite optical depth, and progresses to the cases of semi-infinite and finite atmospheres, the latter lying above a reflecting surface. This section sets the tone for the rest of the book, with meticulous analysis that exploits invariance principles, developments in power series, and asymptotic analysis to discover identities, limits and asymptotic representations of the radiance field. The great value of these results is in part didactic and in part practical, because knowledge of the analytic behaviour of the radiance field guides the design of practical numerical algorithms and provides important test cases.

The second section extends the techniques to atmospheres consisting of a finite number of layers, while the third covers atmospheres in which the optical properties may vary continuously with depth. These sections provide a valuable compendium of the outcomes from many years of research.

The text is tightly focused, which allows Yanovitskij to explore a limited range of problems in depth, but also means that some important topics are neglected entirely. For example, Yanovitskij assumes that the optical properties of the atmosphere are given as data, and thereby side-steps both the physical interaction of radiation with matter and the uncertainties that arise when these interactions are modelled in the real world. Likewise, the entire book is focused on monochromatic radiation, whereas the complex spectrum of the radiation field is critical in modelling the vertical profile of radiative heating in the earth's atmosphere. These omissions are perhaps more noticeable because the title of the text suggests a wider scope.

In summary, Yanovitskij's text is highly specialised and the treatment is highly mathematical. The introductory material is very brief, and is presented with only minimal physical motivation, no doubt because this material was covered so well in the classic texts. Consequently, the text is more a reference text for theoreticians and researchers in radiative transfer than a text for those interested in applications of the theory to real atmospheres. Nevertheless, for those in the former group, this text is a valuable contribution.

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References

- Chandrasekhar, S. 1950. *Radiative Transfer*. Clarendon Press, 393 pp.
Sobolev, V.V. 1975. *Light Scattering in Planetary Atmospheres*. Pergamon Press, 256 pp.
Van de Hulst, H.C. 1957. *Light Scattering by Small Particles*. Wiley, 470 pp.

Ocean Circulation Theory by Joseph Pedlosky (Springer-Verlag, 1996). ISBN 3-540-60489-8. \$130.00.

Pedlosky has summarised the major analytical theories for the general circulation of the ocean. These include a fresh re-appraisal of long-standing theories for the wind-driven circulation in a fluid of uniform density, as well as major advances in understanding of the thermocline and abyssal circulation made up to the mid-1990s. The book will probably be most appreciated by readers who begin with an understanding of the basics of ocean circulation and a familiarity with vector identities and principles from fluid mechanics. The book is a major accomplishment, and is essential reading for anyone interested in understanding the dynamics of the global and basin-scale circulation of the ocean. It is based on an advanced graduate course given in the US, and it is a pity that a similar course is not on offer here in Australia.

The Preface provides an excellent overview of the material covered, which includes Sverdrup theory, the Stommel and Munk models for wind-driven circulation, quasi-geostrophic theory for thermocline motion, the theory of the ventilated thermocline, buoyancy forced circulation, the equatorial undercurrent and the abyssal circulation.

Chapter 1 provides a valuable and sobering discussion of the difficulty in applying Sverdrup theory to regions where there is significant bottom flow over topography, despite the fact that this theory is the cornerstone of other theories discussed in the following sections.

Chapter 2 covers the dynamics of wind-driven circulation in a uniform fluid occurring over a broad parameter range, and would make an excellent inclusion into an introductory course on the ocean circulation as a geophysical problem. The summary reveals unforeseen complexity. It should be said, however, that part of this work is exploratory in nature, and it is not entirely clear if some of the behaviour (the Fofonoff mode, inertial runaway, multiple equilibria under free-slip boundary conditions, and perhaps even the inapplicability of Sverdrup theory in some of the cases mentioned) is relevant to the actual ocean.

Chapter 3 provides an absorbing review of the role of internal Rossby waves in establishing the deep circulation in the interior of a stratified (quasi-geostrophic) ocean. These waves can act to 'switch off' any deep flow excited by an impulsive wind. The mean flow can prevent these waves from entering certain regions, and so the deep motion can continue unabated. Deep motion in a ventilated thermocline, a unified model for deep motion, and a theory for a buoyancy and wind-driven subtropical gyre are then described. This is followed by an interesting discussion of the three-dimensional character of the Equatorial Undercurrent, and how its dynamics are intimately linked with mid-latitudes.

The last chapter enthusiastically conveys the major insights Stommel, in conjunction with Arons and Talley, provided into the nature of the abyssal circulation. In typical Stommel fashion, important and fundamental questions are addressed using simple models which reflect an extraordinary ability to isolate the essential physics, on the basis of limited observational evidence. This is also evident in the remarkable laboratory experiments described, which were designed to test existing theories for the response to imposed sources and sinks. The results are surprising, even startling for the uninitiated: horizontal recirculations are set up over the interior which can dominate the flow that satisfies continuity of mass, leading to volume fluxes which actually oppose the direction expected from the positioning of the source/sink pairs. Pedlosky leaves us with an appreciation of both the strengths and weaknesses of the theory.

He then describes extensions to this model, including his own recent theory for abyssal flow in basins with fractured zones.

Throughout the book, the fragmentary nature of the existing theories is emphasised. For example, none of the thermocline theories incorporate western boundary currents. This motivated Pedlosky to describe a large number of numerical and observational studies which seem to indicate that the limitations do not seem to be crucial – the existence of shadow zones and closed geostrophic contours (into which Rossby waves cannot intrude), for example, are apparent even when the boundary current is present. Extensive discussion of analytic theory, numerical modelling and observations together in the one book makes for fascinating reading and is one of the book's great strengths.

For a book of such breadth, it is remarkably easy to follow. This is due in part to the fact that each chapter and each major subsection begins with an informative introduction which motivates the theory to follow and outlines what is to come. All major mathematical derivations and arguments are accompanied by clarification in the text and some of the derivations are left (appropriately) as exercises for the reader. Each section concludes with a summary of the main theoretical results, together with the main limitations. The latter are then used to motivate the subsequent section.

The discussion is greatly assisted by the inclusion of 167 figures, including many from the original papers reviewed. Numerous key references are provided. The theories are presented in a framework in which their strengths and limitations as well as their inter-relationships are transparent. In fact, the use of scaling arguments in the derivation of the various simplified systems analysed is simply masterful.

My only suggestions for improving the book would be to expand the table of contents to include an extra level of subsections, and to enlarge the subject index, both of which would help to cross-reference material. A final summary chapter highlighting the major strengths and weaknesses of the theories and speculating on where future theoretical developments may occur would have made interesting reading. The incorporation of western boundary currents into the thermocline theories, unification of thermocline and abyssal theories and more realistic models of the sub-polar gyres, for example, would no doubt feature here.

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Encyclopedia of Climate and Weather
 editor-in-chief Stephen Schneider
 (Oxford University Press 1996). ISBN 0-195-09485-9. \$295.00.

One suspects that the appearance of an encyclopedia in any area of study is a landmark in its development. What good scientific reason is there, at last, for the atmospheric sciences to be given such a guernsey of recognition? Some might ask more realistically, what are the reasons for a growth in readership to justify a prestigious publisher to invest in a venture beyond the stage of a text-book, or a coffee table edition of colourful photographs of cumulus clouds?

We can speculate that as a result of the popularisation process, current environmental concerns, especially those associated with the much publicised accelerated global climate change, play a significant role. Indeed, the editor-in-chief, Stephen Schneider, nowadays an ardent advocate of global warming, and earlier, it may be remembered by the more cynical, of global cooling, discusses the potential for environmental degradation and particular climate impacts, the need for atmospheric knowledge to be focussed upon social areas of concern, and the prospects for development in the twenty-first century. In the Preface, he states the purpose of the encyclopedia as a vehicle of communication between atmospheric scientists and the broader society, a vehicle of sufficient capacity to carry both the science and its accumulated baggage of applications. Climate and weather involve more than meteorology, he states. The modern science, technology, and policy needs in this area require knowledge and experience from many disciplines, such as physics, chemistry, forestry, ecology, geography, geology, archaeology, oceanology, glaciology, agronomy, forestry, hydrology, health sciences, economics, history, political science, and literature. Phew... At this stage, we might reflect on how such baggage has been treated in the past. Apart from excellent research periodicals such as *The Journal of Applied Meteorology*, *The International Journal of Biometeorology*, *The International Journal of Climatology* and others, the applications of atmospheric processes and statistics have been systematised within dedicated monographs variously bearing within their titles the words 'Applied Climatology/Meteorology', 'Urban' and 'Boundary Layer' (those by Griffiths, Hobbs, Lamb, Landsberg, Mather, Monteith, Oliver, Oke and others). In the main, these have first advanced relevant discussion of the larger atmospheric processes and data, and then followed with empirical observations of impacts. The more focussed tomes with specialist interests on quantification of the energy fluxes through living systems (e.g. Budyko, Gates, Lowry), human thermophysiology (e.g.

Burton and Edholm, and Winslow, Herrigon and Gage), and historical explanation (e.g. Huntington, Lamb, Markham, Taylor) have tended to be more inductive, starting more often from the consumer's point of view, with definitions of favourable microclimates and impacts. The most recent and comprehensive, Thompson and Perry's (1997) *Applied Climatology*, assumes an advanced level of readership and presents integrations of processes and impacts as self contained within specific 39 problem areas. In all of these, with varying degrees of success, there has been an attempt to link topics along a general theme, or at least to provide an integrated and systematic analysis.

An encyclopedic approach to multidisciplinary problem areas, on the other hand, needs to be somewhat different. Presumably there is the dual need (a) to permit lexicon perusal, definition of phenomena and some inductive investigation of relationships, and (b) to facilitate deduction of details from broader conceptual understanding. By necessity, the reader should be easily able to isolate by keyword a particular topic of interest, and then, depending upon desired emphasis, follow into more generalised areas and theories, and delve into increasing detail and specialisation, without a need for an overall appreciation of the other segments. One presumes in either case, that, in the construction of encyclopaedias, the selection of topics must be based on anticipation of users' alphabetical recognition of relevant terminology and synonyms of related concepts.

Clearly, the first essential must be a sufficient number of entries compiled in a comprehensive index. In this respect, the *Encyclopedia of Climate and Weather* appears to succeed. There are several thousand textual entries, tables, figures and maps, lists of contributors and their affiliations, a glossary and extensive indices and abbreviations. The entries are headed by one or two keywords that are also effectively cross-referenced within the index. Seemingly, most of the commonly recognised terms are included, either by entry heading or within the index. Even to the random peruser of (say) the Hs, there are discourses of varying lengths about hail, Hare, haze, health, heat island effect, history, human life, hydrological cycle and hygrometer. The listing appears to be exhaustive and sensible, although at times there are some very puzzling entries, for example that entitled 'primitive equations', which becomes lengthy and sophisticated enough to earn the author's disclaimer that the first key word is not meant to imply elementary. What purpose such an entry would serve within a general encyclopedia remains obscure.

To go beyond the superficialities of structure, a brief test was conducted with my (non-atmospheric science) tertiary level student family. The first was to ask members to investigate some common atmospheric phenomena, and the second to investigate an application of

interest. The choices for both seemed to be reasonable enough: one the establishment of the difference between a tornado and a tropical cyclone, and the other the role of atmospheric factors in building design.

No entry was found for tropical cyclones, but the index did point to a dozen references, including a handful of pages amongst the cyclones, dealing with their structures and wind speeds. There was an interesting reference to the use of other names for these storms, but also, inexplicably, a major separate section was discovered under the heading of hurricane. This caused no end of confusion. Stylistically, there were considerable differences between the two entries and there was no obvious linkage between the two. Worse still, the hurricane entry gives the impression that this is exclusively an American phenomenon and the uninitiated were left wondering if these storms are different types. This same exaggerated American bias appeared within the tornado entry, but there was insufficient succinct detail supplied to enable clear differentiation of the twister from the tropical cyclone. Unfortunately, this first exercise left the researchers more confused than at the beginning.

The second test fared even worse. The search for housing and/or settlement design degenerated into desultory and unrelated references to climate control, human adaptations, urban heat island and several separate hazards. There was little to learn about deliberate urban atmospheric modification.

The results of these subjective inspections cannot be simply dismissed as matters of random vicissitude. Unfortunately, this remarkable failure to adequately deal with the built environment seems not to be simple oversight, and we need to further consider questions of epistemological validity. In the Preface, Schneider lists numerous problems facing humanity that need to be dealt with. Alternatively, a more systematic approach might be to consolidate these within the two BIG climate related issue areas: (a) provision of food, prevention of desertification and maintenance of biodiversity (atmospheric impacts focussed upon variability and availability of water), and (b) urbanisation and human health (atmospheric impacts focussed upon thermal conditions, air pollution potentials and water again).

Whatever the paradigm for analysis of atmospheric impacts, be it proactive hazards management with emphasis upon adaptation and human response capabilities, or reactive disaster responses with emphasis upon engineering and logistics solutions, the concern needs to be anthropocentric and concentrate upon burgeoning populations in hazard zones. Within the parlance of impacts assessment, some of these issues are first direct order, but in the main they are indirect second and higher order, that is those involving human-generated feedbacks, mostly within modified and built environments. To the comfort and well being of twenty-first century

highly urbanised human populations, the modified boundary-layer structures within settlement atmospheres will become critical. In other words, beyond the impact side, some of the most relevant issues facing climatology and meteorology must be those of downsizing the free atmospheric fluxes to microclimatic ones within techno-cultural envelopes.

Yet, beyond sections on urban health effects, in the encyclopaedia there is no discussion of built environments, indoor climates, thermal comfort or design. Microclimate studies do not go beyond energy transfers within plant canopies and only contain a brief mention of the urban heat island: there is no reference to the pioneering German school of microclimatology, or to architectural sciences. The volumes become largely irrelevant to the engineer, architect and manager of the built environment, the environment of most of humanity. As regards the vast area of thermophysiology, there is quite a voluminous section on the Wind Chill Index, but no reference to the far more universally used indices, including effective temperature and its derivations, or amazingly to the essential work of Gagge, Tromp, Lee, Fanger, the whole of the indoor climate field including ASHRAE, or the current and critical debate on adaptation and passive and low energy options.

This lack of discussion of human impacts and urban-based populations could be placed within the category of omissions, and I think that as such they are serious enough to give the reader an unbalanced interpretation of the purported emphasis of the volumes, that of atmospheric applications. If so, the material can hardly be presented as sufficiently balanced to be objective to the lay reader, or the high school or tertiary level student.

Beyond omission, I believe that the volumes are also seriously flawed in commission, especially again within the areas of what can be broadly termed human biometeorology. Sections dealing with the impacts of weather and climate upon humans and historical events, and biometeorology in general, become distorted through the use of unsystematised materials and in remarkably oversimplistic descriptions of seemingly haphazardly selected events. Here again, the references provided present surprising selections that appear at best to display ignorance of some of the most significant publications within the various fields. How can a serious anthropology or history student not be made aware of the climatic studies of Ellsworth Huntington and Arnold Toynbee, or Frank Markham or Griffith Taylor?

Without specifying sections, in some cases especially where the material becomes unduly selective and where referencing seems to become self-serving, or in those citing relatively minor or derived work, the volumes become downright misleading. Such severe criticisms of course impinge upon the individual authors. But in part blame for this failure must fall upon the

Editor, who in his own words had the '...task to select the editorial advisers and to work closely with them on the topics to be included and the selection of authors and reviewers'. It seemingly also became the Editor's decision to largely avoid control of writing styles: 'We have deliberately aimed for diversity rather than homogeneity'. It becomes very tempting also to suggest that, at least in some cases, individual authors had not been adequately advised of the need for Encyclopedia reviews to be objective, or perhaps the review process failed to pay adequate attention to this dimension.

One of the worst failings is that within the awarding of particular recognition to selected atmospheric illuminati. No worries about the inclusion of the Hares, Koeppens, Lambs and Thornthwaites, but why not the Budykos, Huntingtons, Landsbergs and Austin Millers? And more distantly removed from the usually favoured American-British authors, might the Aussies not barrack for the Gentillis, Walkers and Griffith Taylors, and the Germans for the Brezowskis, Plancks and Geigers, and what of the French and the Chinese and so on? This is hackle raising stuff indeed: what were the objective criteria for selection? No argument that Hubert Lamb is one of the good 'uns, but a description that he is '... arguably the greatest climatologist of the twentieth century', elevates the sin of blatantly parochial commission to one of premeditated crime.

Academic quality aside, is the encyclopedic venture likely to be a financial success? Are the atmospheric science entries, general presentation, diagrams and facility of use likely to be sufficient to ensure the necessary numbers of sales? Who at the recommended price will buy the volumes?

I think that very few students would, as they are far more likely to delve into the more exciting and colourful world of the Internet in search of specific materials, which can also increasingly be found on dedicated CDs. If you need a hard copy reference, there is far better and more up-to-date material available both in current volumes in meteorology and climatology, and on second-hand text-book counters at any self-respecting tertiary institution at a fraction of the cost. Conceivably, there is a place for the *Encyclopedia of Climate and Weather* within the general reference sections of public and maybe educational institution library shelves, but I would not think within the collections of the serious professional, whose preference would lead to more specialist and focussed works.

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