

Book reviews

An Introduction to Environmental Chemistry, 2nd Edition, by J.E. Andrews, P. Brimblecombe, T.D. Jickells, P.S. Liss and B.J. Reid (Blackwell Publishing, 2004). ISBN: 0632059052. 296 pp., \$85 (paperback).

Environmental chemistry is a broad topic with very fuzzy edges. Hence there is a diverse field of scientists that apply environmental chemistry principles. For example Professor Paul Crutzen, who was awarded a Nobel Prize for his work in atmospheric chemistry, was actually an engineer and meteorologist by training. Many people working in the broad area of environmental chemistry are physicists, chemists or biologists.

There is also a diverse field of people that need to know some environmental chemistry, even though they often fall under the heading of 'environmental science'. For this reason, writing a text book to cover environmental chemistry is difficult. What knowledge should be assumed of the reader? What level of detail should be presented, and indeed, what topics should be highlighted? There are a number of textbooks published in this area, each based on a different set of assumptions.

An Introduction to Environmental Chemistry has made some significant choices regarding the target audience. It aims squarely at the starting undergraduate, and assumes that the student has little or no chemical background. As a result, the authors attempt to teach the chemistry within the contextual framework of the environment. The text also assumes little mathematical knowledge and a biological background that is satisfied by cartoons. From this starting point, the authors do not aim to provide an exhaustive coverage of any area, but rather a flavour of some of the large environmental issues and the chemistry underlying them. Finally, it is written from a British perspective, and this directs the focus of the material.

The text has an attractive cover, and in 296 pages, covers seven themed chapters with a comprehensive index at the back. The areas are: 'Introduction' (13 pp.); 'Environmental chemist's toolbox' (17 pp.); 'The atmosphere' (35 pp.); 'The chemistry of continental solids' (75 pp.); 'The chemistry of continental waters' (40 pp.); 'The oceans' (58 pp.); and 'Global change' (43 pp.). The publishers and authors have produced this text at a comparatively low cost to other text, retailing for approximately A\$85.

As the book is an introductory text to both chemistry and environmental chemistry, the authors have dedicated the second 'Toolbox' chapter to some very fundamental chemical principles, including chemical bonding, molarity, basic organic molecular structure and functional groups, the pH scale, and oxidation and reduction reactions. One to two-page 'Boxes' dispersed throughout the rest of the chapters provide the additional chemical tools needed to support specific concepts.

The text is well written and easy to read. Good images and 'Boxes' support the concepts introduced in the text. Figures and tables use a fairly good range of examples from various parts of the world, although with a distinct northern hemisphere bias.

The authors have provided two sections at the end of each chapter – 'Further Reading' and 'Internet Search Keywords'. The section of 'Further Reading' consistently refers the reader to more specialised textbooks. As this text is aimed at tertiary students, this section would be greatly enhanced if it encouraged the use of relevant peer-reviewed journal articles to complement the text. Although some of the 'Internet Search Keywords' were introductory (e.g. water chemistry, soil chemistry, soil pH) and repeated among chapters, the concept of referring students to the internet to promote independent learning and revision of topics to enhance their understanding cannot be encouraged too strongly!

Given the limitations imposed by the audience and space, this book is very good. It introduces numerous key environmental issues well. My first checkpoint is the chemistry of the ozone hole. Although this has been known for nearly 20 years, it is surprising how many texts actually get it wrong. Andrews et al. get it right.

However, for a more specialist audience the limitations will be obvious. For example, the complete lack of meteorology (I find the description of the debris from Chernobyl being 'quickly detected all over the globe' misleading), the strange choice of residence time for nitrous oxide (page 44) of 20-30 years, whereas it is believed to be closer to 110 years (IPCC 2001) and the bizarre description of the structure of the atom given in Chapter 1. The lack of a discussion of acid sulfate soils reduces the book's usefulness from an Australian context.

So, if you are looking to learn (or teach!) some chemistry, and for an appreciation of some of the major issues in environmental chemistry, this is a good place to start. The book is well written and cov-

ers a wide scope. For those of us wishing to teach environmental chemistry to upper undergraduate students, it will unfortunately remain on the shelf.

Stephen Wilson and Dianne Jolley

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Handbook of Atmospheric Sciences Principles and Applications, edited by C.N. Hewett and Andrea Jackson (Blackwell Publishing, 2003). ISBN 0-632-05386-4, US\$304 (hardcover).

This book is not for the fainthearted. With 21 chapters and 633 pages, it is a very extensive and detailed analysis of the current understanding of atmospheric sciences in the early 21st Century. Nor is this book for the novice. For a good understanding of the contents, the reader should have a strong background in atmospheric physics, chemistry, meteorology and climatology. The overall purpose of the book is to provide an evaluation of the state of knowledge about the atmospheric sciences, and to demonstrate a range of applications (focused mainly on air pollution and climate change). To this end, the book is divided into twelve chapters for the background and principles of atmospheric science, and nine chapters on applications. The editors have succeeded admirably in a very difficult task. To gather within a reasonably condensed time frame, 23 chapters from a range of authors, and to maintain an overall high standard across the book, is a major challenge.

In the preface, the editors state that, as an identified need, the book can be used to enhance student understanding of the atmosphere. This is not, however, a classroom textbook for undergraduates. It is a wonderful resource for teaching support, as well as a reference and background for current research understanding. I might ask my upper-level undergraduates to read selected chapters in support of a course.

However, I would recommend purchase only to students who intend to major in atmospheric science and intend to pursue postgraduate work.

The high standard demanded of the editors is demonstrated consistently throughout the book. There are few weaknesses and these are minor. Each chapter is an extensive review. With one exception (Chapter 2 'Energy Structure'), each chapter has a significant range of references to where the reader can visit for further information. The references are largely up-to-date (to the early 2000s), but there is also good use of older 'classics' to provide a solid basis for the discussion. Some examples of strengths include the following.

The book covers a very wide range of atmospheric science topics. It begins with an extensive and detailed review of the evolution and development of the atmosphere, and ends with an assessment of air pollution management strategies, a recognition that human activities are currently the greatest threat to the natural process of the atmosphere.

Most chapters have very useful summaries of the more detailed analysis. This was particularly good in Chapter 6, 'Tropospheric Chemistry', giving the reader pause to think back over the contents. Almost all chapters have useful conclusions, with the exception of Chapter 12, 'Atmospheric Removal Processes'. There is good cross-referencing between chapters, especially in Chapters 7 ('Stratospheric Chemistry and Transport'), and between Chapter 10 ('Atmospheric Dispersion and Air Pollution Meteorology') and Chapter 18 ('Pollutant Dispersion Modelling'). Throughout the book there is a scattering of figures and tables that can be used to great advantage to support teaching.

Many of the applied chapters include very useful discussions on solutions to, or ways to mitigate, problems. For example Chapter 15, 'Urban-Scale Air Pollution' provides comment on ways to minimise pollution through legislative and technical solutions, economic incentives, and city planning. Most of the applied chapters also have sections recognising the limitations in knowledge and the need for truthing of results. Chapter 20 on 'Critical Loads' was especially impressive here, and provided a refreshing way to view air pollution threshold values in relation to human health and the environment.

Any book of this size and with this range of authors can be criticised. My negative comments are minor, and come more under the category of irritations. The book is highly Eurocentric in approach. Aside from a few authors from the United States, there is only one co-author from Asia, and none at all from the southern hemisphere. While this does not detract from the content and quality of

the chapters, it does limit the global range of specific examples used. It also illustrates how, even in a world of instantaneous communication, geographically insular research and teaching groups can remain.

In today's world, internet information and communication is essential. It is therefore very surprising that very few authors referenced internet sources, in support of journal articles and books. Two exceptions to this were Chapter 7, 'Stratospheric Chemistry', which provided a wide range of internet sources on the problem, and Chapter 17, 'Emissions Inventories'.

There are a few sections in some chapters that are based on information that is out of date. For example, the discussion on the global NO_x budget in Chapter 5 ('Biogeochemical Cycles') is based on a 1983 reference. Considerable progress in understanding has been made since then. In Chapter 14 ('Regional Scale Pollution'), the Arctic Haze references are from the 1980s, and there is no discussion of the major air pollution transport problems associated with East and Southeast Asia. A table listing the major regional air pollution transport studies over the past decade, with brief descriptions, would have been very useful here.

Chapter 8, 'Aqueous Phase Chemistry of the Troposphere', has no assessment of fog, and the rate differences between fog and rain. There is, however, some discussion of dew. While this chapter provides a valuable description of aqueous chemistry, there is no attempt to include spatial or geographic variations or even diurnal variations.

The discussion on monitoring techniques in Chapter 16 provides a solid evaluation of surface-based and remote instruments, but makes no attempt to review surface-based siting requirements to ensure regional representation of results. Chapter 18, 'Pollutant Dispersion Modelling', is the only chapter with set-aside case studies to illustrate results. Unfortunately, there are no real specifics about the models themselves, and their contents. Many models are listed, and web site links would have been especially valuable here.

A few chapters try to cover too much material, and therefore subsections are short, with limited information. An example of this problem is Chapter 15, 'Urban-Scale Air Pollution', where especially the sections on dispersion and transformation are too short to be of much value.

Overall, I rate *Handbook of Atmospheric Sciences* as an upper-level high distinction in overall content and value. It provides excellent support material for teaching and for research. It should be on the bookshelf of any professional atmospheric scientist. The

minor problems listed can be overcome in a second edition. The book is a fine example of a high-quality cooperative effort among a group of highly experienced authors.

Howard A. Bridgman

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Forecast Verification. A Practitioner's Guide in Atmospheric Sciences edited by I.T. Jolliffe and D.B. Stephenson (John Wiley and Sons, 2003). ISBN 0-471-49759-2. 240 pp., A\$138.

Forecast verification is a topic that, at first glance, may seem trivially simple. All you need to do is compute the mean error, and maybe the percentage of correct forecasts, right? But as soon as you begin to do forecast verification, it becomes apparent that it is more challenging than first thought. Forecasts are verified to: (a) assess the quality of forecast systems and monitor their performance over time; (b) suggest ways in which forecast systems can be improved to give better performance; and (c) compare different forecasting systems. These tasks call for different sorts of verification methods, from simple summary scores to more complex diagnostic methods. The variety of forecast types (deterministic versus probabilistic, categorical versus continuous, point versus spatial, etc.) require different verification strategies. So, in general, mean error and percentage of correct forecasts just won't cut it.

Forecast Verification: A Practitioner's Guide in Atmospheric Sciences, edited by Ian Jolliffe and David Stephenson, addresses the myriad issues involved in verifying forecasts, and presents methodologies that can be used to evaluate not just the quality of forecasts (i.e. correspondence of the forecast values to those observed) but also their value (e.g. usefulness in enabling a user to make a better decision). It updates the previous standard texts by Stanski et al. and Wilks to include more recent developments in the application of signal detection theory, spatial forecast verification, and ensemble forecast evaluation, among other things. It presents not just the

methods, but also their interpretation and, in many cases, examples. This book is pitched to professionals, but is also appropriate for graduate students.

Each chapter was written by one or more experts, addressing various aspects of forecast verification. As hinted by the book's title, most chapters present information on how to verify a particular type of forecast. The introductory chapter describes the history and current practice of forecast verification, and includes issues that should be considered (purpose of the verification, data quality, etc.) before the actual verification process begins. The second chapter introduces some basic statistical concepts that underlie most verification methods. Exploratory methods such as box plots, histograms, scatter plots and contingency tables showing the frequency of each combination of forecast and observed category, are nicely illustrated, as are the usual statistical measures of mean, standard deviation, and so on. Probability concepts are introduced, but then the chapter bogs down in the description of Murphy and Winkler's general framework for forecast verification based on the joint distribution of forecasts and observations (this topic is discussed again in Chapter 3).

The third chapter, written by Ian Mason (recently retired from the Bureau of Meteorology's Canberra office), describes in great detail how to verify forecasts of binary, or yes/no, events. There is a richness of verification scores to assess this sort of forecast, many dating to the 1880s, and others the topic of recent research. The equations are presented using two and sometimes three views: the traditional contingency table elements of hits, misses, false alarms, and correct rejections; the likelihood-base rate factorisation elements of hit rate, false alarm rate, and base rate (climatological frequency); and in terms of conditional and marginal probabilities. Confidence intervals and optimal probability thresholds (where appropriate) are also given. The latter part of Chapter 3 describes the use of signal detection theory and the relative operating characteristic (ROC) in forecast verification. An example of how to generate a ROC curve for probability forecasts in discrete categories would have been useful.

Verification of multi-category forecasts is described in Chapter 4. Although the traditional multi-category Heidke and Pierce skill scores are presented, their use is discouraged in favour of the more equitable (meaning that random and constant forecasts yield the same poor score) Gerrity and LEP-SCAT scores developed during the 1990s. These make use of a scoring matrix which, when multiplied by the contingency table, gives the final score. It is important to include confidence intervals on the sample verification scores to determine whether the fore-

casts show real skill or whether their success was just a fluke. This chapter describes some resampling methods that can be used to estimate CIs.

Chapter 5, on the verification of forecasts for continuous variables, presents the familiar error measures such as bias, mean absolute error, root mean squared error, etc., all demonstrated on a set of temperature and precipitation forecasts. There is some very interesting discussion on various correlation coefficients (yes, there is more than one).

The next chapter discusses the verification of spatial forecasts and some of the issues unique to their verification, such as dealing with observations with irregular spacing, point-to-area conversion of quantities, and time/space partitioning of the samples. Although the standard error measures introduced in Chapter 5 are frequently used, there are other verification methods specifically suited to spatial forecasts. These include the anomaly correlation, S1 score (used mainly for historical reasons), principal component analyses (often called EOF analysis in meteorology), signal detection analysis, feature-based methods, and spatial decomposition. Because many of these methods are somewhat complex, this chapter describes them fairly briefly and refers the reader to the meteorological literature for more information.

Ensemble forecasts are verified using traditional scores appropriate for probabilistic forecasts of any type, as well as several new methods developed specifically for evaluating ensembles (Chapter 7). This chapter was written by four authors and contains a frustrating amount of repetition, while some methods (ROC, information content, ranked probability score) were only briefly described and not sufficiently interpreted. The mathematics in this chapter was not very user-friendly, often making use of integrals and expectation notation instead of the discrete summations used in practice. In spite of these negative aspects, this chapter contains much useful information on evaluating ensemble forecasts, including reliability diagrams, the Brier score and its decomposition into reliability, resolution and uncertainty components, summary statistics describing ensemble mean error and spread, rank histograms, and other diagnostics. The verification of ensemble forecasts is very much a topic of current research, and the authors state that the relationship between different verification scores for probabilistic forecasts is not well understood, nor is the selection of the 'best' score for each application.

Chapter 8 on economic value and skill nicely describes how the simple cost-loss decision model can be applied to assess the usefulness of a forecast system. The advantages of probabilistic forecasts over deterministic forecasts in aiding decision-making are

clearly shown. This chapter also gives a nice explanation of why the Brier and ROC skill scores often present differing pictures of forecast usefulness, which relates to the assumed distribution of user cost/loss ratios.

The book concludes with a chapter on the past, present, and future of forecast verification, highlighting key concepts from earlier in the book and discussing some verification methods used in economics, medicine and other disciplines. The authors suggest several areas in need of future research, including verification of complete probability distributions and verification of non-stationary data and extremes.

In summary, I believe that *Forecast Verification. A Practitioner's Guide in Atmospheric Sciences* is a very useful book, not just for its abundant information on how to verify forecasts, but also, importantly, how to interpret the verification results.

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