Reviews

DeWALLE, D.R. and A. RANGO. 2008. *Principles of snow hydrology*. Cambridge, etc., Cambridge University Press. 410pp. ISBN 978-0-521-82362-3, hardback. £75/US$150.

In a recent review paper, Barnett and others (2005) estimated that river basins in which runoff is dominated by snowmelt and in which reservoir storage is inadequate to buffer predicted seasonal shifts in runoff are home to about one-sixth of the world's population and responsible for a quarter of the global gross domestic product. An understanding of snow hydrology is vitally important for management of water resources and prediction of climate impacts in these areas. Although the marvellous *Handbook of snow* edited by Gray and Male (1981) has recently been reprinted by Blackburn Press and still provides a valuable reference, there have been many changes in the field since 1981, and not all of them have been positive: great advances in modelling and remote sensing of snow do not fully compensate for declines in hydrological monitoring networks that were already sparse in northern areas. The new *Principles of snow hydrology* by DeWalle and Rango therefore provides a timely primer in this important area of study. I would have said that Cambridge University Press are building up an impressive catalogue in snow science, adding this volume to the earlier *Snow ecology* (Jones and others, 2001) and *Snow and climate* (Armstrong and Brun, 2008), but the former is currently out of print.

An interesting but rather brief introductory chapter skips through societal perceptions (or ignorance) of snow, the history of snow hydrology and major research basins, and the physical properties of liquid and frozen water. The second chapter covers the formation and distribution of snow, from the large scales of mountain ranges and frontal systems to small-scale influences of wind and vegetation. A useful feature, introduced here in the discussion of blowing snow and maintained throughout the book, is that example numbers are plugged into equations wherever they are introduced, to give the reader a feeling for the magnitude of terms. Another feature that soon becomes apparent is that, although international research is reviewed, this book has a strong geographical focus on the conterminous USA (three-quarters of the figures in the book that have an identified location are for the USA). This appears to be a deliberate and understandable decision to concentrate on the authors' areas of expertise. It does, however, mean that there is much more material on snow and runoff processes at high elevations than high latitudes; much recent interest in snow hydrology has been driven by concerns about impacts of changing runoff in the Arctic on sea ice and ocean circulation. The authors also warn us in the preface that they will be largely neglecting glacial hydrology.

Under the heading 'Snowpack condition', chapter 3 discusses the microphysical processes of heat and water transfer in snow. The following two chapters contrast ground-based and remote methods of snow measurement. A striking feature of the ground measurement chapter is how relatively few recent papers are referred to: there are more references pre-dating 1970 than there are from this century. Rather than a failure on the part of the authors to stay up to date or an indication that the problems of measuring snow on the ground have long since been solved, I take this as a sign that relatively little progress has been made recently on the outstanding problems. The chapter ends with a rather technical description of snow crystal imaging by electron microscopy that seems a little unbalanced; few readers will have the facilities to reproduce these procedures, and more examples and discussion of the fascinating images obtained by this method would have been interesting instead. The chapter on remote sensing covers many instruments and several regions of the electromagnetic spectrum used for snow mapping and includes some examples of hydrological applications of remotely sensed snow information.

Chapters 6 and 7 return to physical processes: first the radiative, turbulent, advective and internal energy balance of level, exposed snowpacks, and then the influences of topography and forests. These are areas of particular challenge and considerable research interest in large-scale snow modelling. The authors rather give the impression that energy-balance models are not widely used; this is probably true in operational hydrology, where the requisite input data are often unavailable, but in fact many energy-balance snow models have been developed (e.g. Slater and others, 2001), and such physically based models are essential for climate prediction. The subject of snow chemistry, which is of increasing interest and crucial for the water quality aspects of snow hydrology, is dealt with quite briefly in chapter 8, but this section does allow the authors to mention stable isotopes, which are important for meltwater-tracing studies discussed in the following chapter. For a more detailed discussion of photochemical processes in snow, see the recent reviews by Dominé and others (2007) and Grannas and others (2007).

The chapters that I found most interesting – 9 and 10 – deal with the processes that convert snowmelt to streamflow, and the integrated modelling of these processes. One comment I would add is that statistical modelling is an expanding area, with increasing interest in the use of ensemble techniques for snow hydrology (e.g. Andreadis and Lettenmaier, 2005). Although energy-transfer processes are covered well in earlier chapters, the discussion in chapter 10 again focuses on temperature-index models; such models are still widely used, but their utility in the predictions for ungauged basins and changing climates that hydrologists are increasingly called upon to make is severely limited.

The Snowmelt-Runoff Model (SRM), in the development of which Rango has been closely involved, is discussed at some length in chapter 11, the longest chapter in the book. For casual readers, the detail in this description of a single model may be excessive, but this section will be of use to those using this book as a text for a snow hydrology course. A particularly valuable feature is the internet link provided to download SRM, which comes with an extensive user manual, online help and several example input files. When I tried this out, I had installed the model, run a simulation and was looking at graphical output within 5 minutes of typing in the URL.

The concluding chapter on snow management seems a little out of place and contains material that could mostly have been absorbed into earlier chapters. The discussion of climate impacts on snow hydrology is extremely cursory. Two appendices give physical constants and methods for calculating solar irradiance on sloping surfaces.

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Although DeWalle and Rango do not provide an exhaustive survey of the methods and applications of snow hydrology, filling the gaps that I have hinted at would likely produce a cumbersome and less readable volume. The authors state in the preface that this book has developed from their experiences of teaching snow hydrology classes and is intended as a text for upper-level undergraduate or graduate classes; it will serve this purpose well. Like the earlier snow science publications from Cambridge University Press, *Principles of snow hydrology* is handsomely produced and lavishly illustrated but not cheap. The price may deter all but the most dedicated students of snow hydrology, but it will be a useful addition to the bookshelf of anyone teaching a course or conducting research in this area.

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