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BOOK REVIEW

NUMERICAL MODELING OF OCEAN CIRCULATION, by Robert N. Miller. 2007. Cambridge University Press. 242 pages. ISBN 9780521781824.

'Oceans are an essential part of the climate system' begins the front matter. Numerical ocean modelling is a key element of modelling and understanding the climate system. Twenty years ago it would have been rare for an observational oceanographer to consult numerical model output in planning a field campaign. Today the reverse is true. Numerical modelling of the ocean, for a variety of applications, has made great advances both through increase in computational resource and the advances in our ability to effectively use that resource.

Numerical Modeling of Ocean Circulation grew out of a graduate level course at Oregon State University. It provides an introduction to students with a background in theoretical physical oceanography and some familiarity with numerical analysis. There is a concentration on finite differences that reflects the popularity of this method with the wider ocean modelling community.

The book begins with a brief introduction to numerical analysis. The one-dimensional advection equation is used as a prototype to illustrate ideas of consistency, stability, convergence, numerical dissipation and numerical dispersion. More detail in this chapter would be of benefit. There follows an admirable chapter on the numerical solution of the shallow water equations. The reader is taken from the basic one-dimensional linear problem to fully non-linear gyre solutions. The role of staggered grids and conservation laws are examined. The exercises at the end of these early chapters are helpful in reinforcing and exploiting the knowledge gained.

The largest chapter covers primitive equation models. It follows the pioneering approach taken by Bryan and Cox at the Geophysical Fluid Dynamics Laboratory, Princeton, in the 1960s. A rigid-lid and stream function formulation for the barotropic mode provides a particular focus of attention. This is fine from an historical perspective but more modern free surface methods should be covered in at least as much detail. The chapter includes some excellent case studies taken from classic papers on the spin-up of three-dimensional models and the importance of vertical resolution. Alternative vertical coordinate systems (different to the standard z-level) are introduced and the pros and cons of these examined.

The chapter ends with a discussion of the results from a number of fine-resolution models (up to $1/10°$ in the horizontal).

The book concludes with three short chapters on quasi-geostrophic models, models of the coastal ocean and models of the tropical ocean. The chapter on quasi-geostrophic models was too short to be useful and could easily have been omitted. Coastal models are covered by three descriptive case studies of peer-reviewed research papers. Two of the studies utilize the Princeton Ocean Model (POM) while the third demonstrates the benefits of the finite element method. The exercises at the end of this chapter are largely unrelated to numerical modelling. The chapter on the tropics includes a theoretical treatment of equatorial waves and a discussion of the behaviour of these waves in a variety of numerical models.

The aim of the book is to 'provide the student with the context in which discussion of numerical modelling is conducted', rather than a 'state of the ocean modelling art'. This leaves large gaps, self-acknowledged in some cases, for example, parameterization of turbulent processes, data assimilation, and the treatment of surface forcing and boundary conditions. However, much effort is put into open boundary conditions, which could be regarded as more peripheral and yet are discussed in quite some detail in a number of chapters.

Overall the book is written in a very readable style. The figures are of good quality and the reproductions are often better than the online versions available from original publishers. The index is rather limited. The publisher promises additional online resources, but there appears to be nothing available that is not in the book (Table of contents, Excerpt, Index, Copyright and Front matter). There are a few typographical and minor errors (as with many first editions). However with some updating in a second edition this could become a very good first text in numerical ocean modelling.

David Stevens
University of East Anglia, Norwich, UK