Preface

This book focuses on the dynamics of the ocean being influenced by the Earth's rotation and density stratification. Fluids in motion are a difficult subject of study that traditionally requires advanced knowledge of analytical mathematics, in particularly matrix algebra, differential and integral calculus, and complex analysis. Hence, this fascinating field of science, known as *geophysical fluid dynamics*, is accessible only to a limited number of students – those who either are naturally geniuses or those who underwent tough years of intense University study.

Fluid processes are inherently complex and analytical solutions describing fluid dynamics exist only in a few instances and only under highly simplified assumptions. Computer-based numerical models are required to approximate fluid behavior in more realistic situations. Because of its complexity, universities tend to offer subjects in computational modelling of fluid dynamics only at postgraduate level. This is a pity given that fluid processes are truly fascinating in nature and given that the oceans play a significant role in shaping life on Earth.

The approach I pursue in this book is different from the traditional approach. Here, numerical models are gradually built up and refined with the objective to illustrate and explore various dynamical processes occurring in fluids. Little mathematical background knowledge is required, and the focus is placed where it should be, namely on the physics inherent with fluids in motion. This book is a combination of a textbook and a workbook including more than 20 computer-based exercises, written in FORTRAN 95. Analytical solutions of certain fluid phenomena are used as invaluable benchmarks for verification of these model simulations. In parallel to this book, the reader is encouraged to consult textbooks by Cushman-Roisin (1994), Pond and Pickard (1983) and Gill (1982).

The modelling-based approach has many advantages over the traditional analytical approach and, in the author's belief, will open the field of geophysical fluid dynamics to a much broader audience. Obvious advantages are that (a) complex fluid processes such as barotropic or baroclinic instabilities, otherwise exclusively reserved to experts, can be studied by a lay person, (b) instead of still pictures of results, the reader can create animations of processes, and (c) the reader can adopt computer codes, provided in this book, in a modified form for own independent studies. Without doubt, learning is greatly enhanced by playing and this book provides the reader with the tools (or toys) to achieve this.

Access to a standard computer is the only requirement for the completion of exercises. All computer software suites required are open-source programs being freely available for download from the Internet. This book is designed such as to keep financial burden for the interested reader at a minimum. Background knowledge in scientific computing is an advantage but not a requirement.

This book introduces the reader to conservation principles obeyed by fluids in motion, the finite-difference formulation of these principles, and provides the reader with a step-to-step guide to so-called *finite-difference layer modelling*. This book details numerical methods including a flooding algorithm, semi-implicit treatments of both the Coriolis force and bottom friction, and total-variation diminishing (TVD) advection schemes that are absolute minimum requirements for adequate modelling of fluid processes. Further simplification seems not possible, but there are certainly more accurate (but also mathematically more difficult) methods available. A description of higher-order, more complex methods is beyond the scope of this book.

I dedicate this book to my doctorfather Professor Jan O. Backhaus for his creativity and overwhelming enthusiasm which have been the prime motivation for me to pursue a career in the field of physical oceanography. Many of Jan's suggestions and approaches to numerical modelling are implemented in this book.

Other invaluable sources of motivation behind this work are the classical books of Henry Stommel, namely "An Introduction to the Coriolis Force" published in 1989 and co-authored by Dennis Moore, and "A View of the Sea", published in 1987. Similar to the approach I take here, Stommel's work underpinned theory with computer programs, written in BASIC, that can be run by the reader for independent studies.

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