Topographic Effects in Stratified Flows

Covering both theory and experiment, this text describes the behaviour of homogeneous and density-stratified fluids over and around topography. Its presentation is suitable for advanced undergraduate and graduate students in fluid mechanics, as well as for practising scientists, engineers and researchers.

Using laboratory experiments and illustrations to further understanding, the author explores topics ranging from the classical hydraulics of single-layer flow to more complex situations involving stratified flows over two- and three-dimensional topography, including complex terrain. A particular focus is placed on applications to the atmosphere and ocean, including discussions of downslope windstorms, and of oceanic flow over continental shelves and slopes.

This new edition has been restructured to make it more digestible, and updated to cover significant developments in areas such as exchange flows, gravity currents, waves in stratified fluids, stability and applications to the atmosphere and ocean.

PETER G. BAINES is an Honorary Senior Fellow in the Department of Infrastructure Engineering at the University of Melbourne. He is a winner of the Priestley Medal and a Fellow and first President of the Australian Meteorological and Oceanographic Society. He is currently Secretary of the Royal Society of Victoria.

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Peter G. Baines
Frontmatter
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University of Melbourne

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In memory of Adrian Gill and Angus McEwan.

Some books are to be tasted, others to be swallowed,
and some few to be chewed and digested.
FRANCIS BACON, 1561–1626; *Essay 1, Of Studies.*

Contents

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Peter G. Baines
Frontmatter
More Information

Preface to the Second Edition

The main objective of this second edition is to bring the topic up to date at time of writing (~2019 to early 2020). The material covered is somewhat broader: every topic described in the first edition is included here, and a number of new topics such as downslope flows and waves in the upper atmosphere have also been added. In addition, some corrections have been made, and more emphasis has been given to applications. These are becoming more apparent as observations in the ocean and atmosphere improve. The effects of rotation have still largely been omitted, though the Coriolis force/frequency does get an occasional mention. There is a finite limit to everything.

To some extent, the subject is a closed book (or at least, more so than for the first edition), but the type of analysis described here may (or does) have application to other fields. Two under-developed topics that have been proposed are non-linear optics and Bose–Einstein condensates. The latter is probably relevant to the missing mass of the universe.

I would also like to express my appreciation of the work of the staff of Cambridge University Press, particularly David Tranah, for his support and professionalism, and to Leon Chan and Jimmy Philip for assistance with some simulations and figures.

Preface to the First Edition

This project was conceived about 10 years ago, but the incentive to pursue and complete it was hampered until recently because of several fundamental unresolved questions about the nature of stratified flow around topography. Within the last few years it has become possible to answer these questions, as a result of the efforts of several people, and the answers are embodied in the synthesis presented here.

Who will benefit from purchasing, reading or thumbing through this book? It is primarily addressed to fluid dynamicists, meteorologists, oceanographers, engineers, physicists and mathematicians who wish to learn more about the dynamics of stratified fluids. Some background in fluid dynamics is probably necessary, but the subject is treated from first principles and is developed from simple situations toward more complex ones. Overall, the order of presentation is based on logic rather than the historical development. There is balance between theory and experiment, where the comparison is made whenever possible, and a consistent attempt has been made to provide a physical understanding of the phenomena involved.

I have gone to some length to make the material easily assimilable, as the number of figures testifies. As I see it, a book such as this is the next step in the scientific process of the documentation of a subject, following the initial “source" material in journals. It is a documented attempt to digest such material, and should therefore be easier to read. However, much of the material presented here is new, as part of the process of filling gaps and providing a (more) complete picture. A number of new experiments have been carried out at Aspendale specifically for this volume.

I have attempted to give an adequate list of references so that readers can delve deeper into the subject, but it is not exhaustive, and some relevant work may have been omitted. I apologise in advance to any colleagues to whom due reference has not been given.

In its present form, this book has been made possible by the dedicated and professional efforts of several people at Aspendale: most notably David Murray, who has played a major part in most of my experimental studies over the past 10

years; David Whillas, whose talents are evident in several photographs; and Sean Higgins, who has skillfully adapted and created many of the line drawings. Thanks are also due to others who have provided continual background support.

I am grateful to several colleagues who have contributed photographs or figures, and to various copyright holders for permission to use some figures, and these are acknowledged in the captions. I am also grateful to others who have taken the time to read and comment on drafts of chapters in varying degrees of imperfection, and specifically these include Jim Rottman in particular, and Ian Castro, Terry Clark, Jack Katzfey, Peter Killworth, Greg Lawrence, Mike Sewell, Bill Snyder, Larry Armi and Sharan Majumdar. Thanks are also due to numerous colleagues for informative discussion on the material of this book over many years, to George Batchelor for his advice and support, and to Alan Harvey, Brian Watts and the staff of Cambridge University Press for their cooperation and attention to detail.