

Cambridge University Press
978-0-521-02595-9 - Sea Breeze and Local Winds
John E. Simpson
Frontmatter
[More information](#)

The sea breeze affects our lives in many ways, it controls our local weather, not only on the coast but also in many districts inland. Air pollution and smog, the distribution of airborne insect pests and the spread of pollen are all controlled by the sea breeze. In the world of sport it is important to glider pilots, sailors and surfers, and balloonists.

In this book we see how radar, lidar and satellite photography have helped to forecast and map sea breeze and the all-important 'sea-breeze front'. The book ends with a description of laboratory experiments, mostly carried out by the author and his co-workers, and a simple summary of theoretical models. This book will be welcomed by those researching in the subject but will also be valuable to the general reader who is interested in local weather and the natural environment.

Cambridge University Press
978-0-521-02595-9 - Sea Breeze and Local Winds
John E. Simpson
Frontmatter
[More information](#)

Sea breeze and local winds

Cambridge University Press
978-0-521-02595-9 - Sea Breeze and Local Winds
John E. Simpson
Frontmatter
[More information](#)

Sea breeze and local winds



JOHN E. SIMPSON

Department of Applied Mathematics and Theoretical Physics, University of Cambridge



Cambridge University Press
 978-0-521-02595-9 - Sea Breeze and Local Winds
 John E. Simpson
 Frontmatter
[More information](#)

CAMBRIDGE UNIVERSITY PRESS
 Cambridge, New York, Melbourne, Madrid, Cape Town, Singapore, São Paulo

Cambridge University Press
 The Edinburgh Building, Cambridge CB2 2RU, UK

Published in the United States of America by Cambridge University Press, New York

www.cambridge.org
 Information on this title: www.cambridge.org/9780521452113

© Cambridge University Press 1994

This publication is in copyright. Subject to statutory exception and to the provisions of relevant collective licensing agreements, no reproduction of any part may take place without the written permission of Cambridge University Press.

First published 1994
 This digitally printed first paperback version 2006

A catalogue record for this publication is available from the British Library

Library of Congress Cataloguing in Publication data

Simpson, John E., 1915–
 Sea breeze and local winds / John E. Simpson.
 p. cm.
 Includes bibliographical references and index.
 ISBN 0 521 45211 2
 1. Sea breeze. I. Title
 QC939.L37S56 1994
 551.5'185–dc20 93-29979 CIP

ISBN-13 978-0-521-45211-3 hardback
 ISBN-10 0-521-45211-2 hardback

ISBN-13 978-0-521-02595-9 paperback
 ISBN-10 0-521-02595-8 paperback

Contents

<i>Foreword</i>	xi
<i>Preface</i>	xiii
1 <i>The sea breeze</i>	
1.1 Introduction	1
1.2 Sea-breeze clouds	3
1.3 The sea breeze in history	4
1.4 The onset of the sea breeze	6
2 <i>Formation of the sea breeze</i>	
2.1 Land and sea-breeze generation	7
2.2 Pressure patterns and the sea breeze	7
2.3 Sea-breeze strength and direction: hodographs	12
2.4 Horizontal extent of the land–sea-breeze system	19
3 <i>Sea-breeze fronts</i>	
3.1 Structure of a sea-breeze front	27
3.2 Generation of sea-breeze fronts (frontogenesis)	32
3.3 Clouds at the sea-breeze front	34
3.4 Advance of sea-breeze front	36
3.5 Retreating sea-breeze fronts	42
3.6 Sea-breeze undular bore	46
4 <i>Sea-breeze forecasting</i>	
4.1 Land and sea temperatures through the year	49
4.2 Sea-breeze index	50

4.3	Prediction of inland penetration	52
4.4	Forecasting from the state of the tide	55
5	<i>Other local winds</i>	
5.1	Winds from diurnal heating on mountains	59
5.2	Orographic winds	68
5.3	Other local winds induced by differential heating	74
6	<i>Air quality</i>	
6.1	Pollution	85
6.2	Pollution in the sea breeze	85
6.3	Pollution at sea-breeze fronts	88
6.4	Diurnal recycling of pollution	91
6.5	Chemistry of sea-breeze pollution	94
7	<i>Sea breeze interactions</i>	
7.1	Sea-breeze convergence zones	101
7.2	Effects of headlands and peninsulas	101
7.3	Bifurcations	105
7.4	Meetings of fronts	106
7.5	Head-on collisions	108
7.6	Islands	113
7.7	Land-breeze convergence	116
8	<i>Life and the sea breeze</i>	
8.1	Pollen	121
8.2	Insect pests	124
8.3	Birds and the sea breeze	133
8.4	The sea breeze and humans	136
9	<i>Sports</i>	
9.1	Gliding and the sea breeze	141
9.2	Ballooning and the sea breeze	145
9.3	Sailing	148
10	<i>Technology: field measurements of the sea-breeze</i>	
10.1	Near the ground	157
10.2	Airborne measurements	165
10.3	Remote sensing: radar	167
10.4	Remote sensing: acoustic sounding or sodar (sonar)	175

<i>Contents</i>		ix
10.5	Remote sensing: lidar	176
10.6	Satellite imagery	178
11	<i>Laboratory measurements</i>	
11.1	'Land- and sea-breeze' simulation in water tanks	183
11.2	The generation of sea-breeze fronts	185
11.3	Sea-breeze fronts	190
11.4	Use of tanks with moving floor	195
11.5	Ambient stratification: two-layer system	196
11.6	Collision of fronts	200
11.7	Requirements of laboratory models	204
12	<i>Theoretical models</i>	
12.1	Analytic models	208
12.2	Numerical models	214
	<i>References</i>	221
	<i>Index</i>	229

Foreword

Everyone depends on the atmosphere for their breathing, for its protection of the earth's surface from the solar radiation, its winds for ventilation and transport, its rain which feeds the crops and its clouds which help prevent us freezing or roasting. Of course there have been many books ranging from the most popular to the most learned on the atmosphere and its motion. But few books have focussed on the special features of the atmosphere caused by the effects of the sea on the climate and weather of land areas near the coasts. Since most people in the world live within 200 km of the coasts, it is not surprising that this aspect of meteorology has been important since the time of the ancient Greeks.

John Simpson has always been an active meteorologist, during his career as a glider pilot, a science teacher and latterly a university research scientist, and an excellent photographer. I have known him as a colleague at Cambridge over the past 17 years and was guided by him to see the atmosphere with new eyes. Firstly we all learnt, after he arrived in Cambridge, that indeed sea breezes reached us at about 7pm (7 arrived in the remarkable summer of 1976). He had set up a set of stations between us and the coast to track its movement. He also began to interest a number of colleagues to join with him in a series of laboratory experiments that quite changed the scientific understanding of 'gravity currents', which are the basic mechanism for driving the cool sea breezes inland. He has received visitors from far and wide and had an enormous correspondence; there is no sea breeze in the world that he has not heard about. This book is an excellent account of them; their history, their different types depending on the coastline or the synoptic situation, their connection with local weather such as clouds and rain, their effects on pollution, aircraft and bird flight, their measurements which nowadays includes radar, and finally some of the laboratory studies at Cambridge and elsewhere.

*Professor Julian Hunt, FRS
Chief Executive, Meteorological Office, Bracknell*

Preface

I first met the sea breeze over 50 years ago when, due to my ignorance of its existence, I landed a glider downwind after a long flight to the east coast. The result of this ignorance was nothing worse than an over-shoot into a field of beans.

My later experience of the sea breeze was obtained in gliders, finding out the nature of the sea-breeze front. This led to a career in Applied Mathematics developing an interest in the physics of the atmospheric boundary layer, backed up with laboratory experiments. In all this, aspects of the sea breeze kept turning up.

The first nine chapters of the book are aimed at the general reader; they deal with the behaviour of the sea breeze and details which can be seen both from the ground and from the air. Other local winds, some of which are closely related, are also dealt with in this section. It is shown that the sea breeze affects the lives of humans in many ways, for example in the distribution of pollution and in the ways in which people spend their leisure time. The last three chapters are slightly more technical and deal with measurements of sea-breeze phenomena.

I am grateful to Professor Julian Hunt for writing the Foreword to this book and for the help of Professors R.S. Scorer, Herbert Huppert and to Drs. Anthony Edwards and John Chapman for reading the text and for their helpful comments. My thanks go to Margaret Downing for her able preparation of the diagrams and to Jason Newling for photographic work.

Ken Griffin's water colour of the 'sea breeze tree' on the coast of Majorca inspired the design for the cover of the book.