CAMBRIDGE

Cambridge University Press
978-0-521-62430-5 - Polar Lows: Mesoscale Weather Systems in the Polar Regions
Edited by Erik A. Rasmussen and John Turner
Frontmatter
More information

Polar Lows

Mesoscale Weather Systems in the Polar Regions

Polar Lows provides a comprehensive review of our understanding of the small, high latitude weather systems known as polar lows. These often vigorous depressions are a hazard to maritime operations and high latitude communities, yet have only been investigated in detail since the 1960s. In this volume the authors describe the climatological distribution of these lows, the observational investigations into their structure, the operational forecasting of polar lows and the theoretical research into why they develop. They also discuss the experiments carried out with high resolution numerical weather forecast models that have demonstrated how some polar lows can be predicted a day or more in advance.

The book has been written by a number of experts within the field and has been carefully edited to form an integrated, cohesive volume. It will be of value to meteorologists and climatologists with an interest in the polar regions, as well as professional weather forecasters concerned with these areas. It may also be used as a supplementary text on graduate courses concerned with high latitude geography, meteorology, and climatology.

ERIK RASMUSSEN began his career as a meteorologist at the age of 17, in 1952, as flight forecaster in Kastrup Airport, Copenhagen. Following a Masters Degree in 1964 he worked at the Danish Meteorological Institute from 1964 to 1968. Since then he has been affiliated to the Geophysical Department in the University of Copenhagen, where he is currently Professor Emeritus. Professor Rasmussen received a Ph.D. in 1974 for his work on spectral models, and in 1989, the D.Sc. degree for his work on polar lows. He has also spent time working for the World Meteorological Organization in Barbados and, on sabbatical, at Colorado State University and at the Navy Postgraduate School, California, USA. Professor Rasmussen was a co-editor of *Polar and Arctic Lows* (1989) and has also contributed to *Images in Weather Forecasting* (Cambridge University Press, 1995), *Encyclopedia of Climate and Weather* (1996), and *Storms* (1999).

JOHN TURNER has been a research meteorologist at the British Antarctic Survey since 1986 and currently leads the project Variability of the Antarctic Climate System. His present research interests include how ENSO affects the Antarctic climate, Antarctic weather forecasting, high latitude precipitation, and polar lows. Prior to joining BAS, he worked at the Meteorological Office from 1974 to 1986 where he was involved in numerical weather prediction and satellite meteorology. Dr Turner is currently President of the International Commission on Polar Meteorology and Chairman of the Physical Sciences Standing Scientific Group of the Scientific Committee on Antarctic Research. He has been a Fellow of the Royal Meteorological Society since 1974 and served on the Society's Council. Dr Turner edited the journal *Weather* for three years and is also the co-author of *Antarctic Meteorology and Climatology* (Cambridge University Press, 1997).

© in this web service Cambridge University Press www.cambridge.org

CAMBRIDGE

Cambridge University Press
978-0-521-62430-5 - Polar Lows: Mesoscale Weather Systems in the Polar Regions
Edited by Erik A. Rasmussen and John Turner
Frontmatter
More information

© in this web service Cambridge University Press www.cambridge.org

CAMBRIDGE

Cambridge University Press
978-0-521-62430-5 - Polar Lows: Mesoscale Weather Systems in the Polar Regions
Edited by Erik A. Rasmussen and John Turner
Frontmatter
More information

Polar Lows

Mesoscale Weather Systems in the Polar Regions

EDITED BY

ERIK A. RASMUSSEN
Emeritus Professor, Department of Geophysics, University of Copenhagen

and

JOHN TURNER
Physical Sciences Division, British Antarctic Survey

CAMBRIDGE
UNIVERSITY PRESS

© in this web service Cambridge University Press www.cambridge.org

CAMBRIDGE

Cambridge University Press
978-0-521-62430-5 - Polar Lows: Mesoscale Weather Systems in the Polar Regions
Edited by Erik A. Rasmussen and John Turner
Frontmatter
More information

CAMBRIDGE
UNIVERSITY PRESS

University Printing House, Cambridge CB2 8BS, United Kingdom

Cambridge University Press is part of the University of Cambridge.

It furthers the University's mission by disseminating knowledge in the pursuit of education, learning and research at the highest international levels of excellence.

www.cambridge.org
Information on this title: www.cambridge.org/9780521624305

© Cambridge University Press 2003

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 2003

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

Library of Congress Cataloguing in Publication data

Polar lows / edited by E.A. Rasmussen, J. Turner.
p. cm.
Includes bibliographical references and index.
ISBN 0 521 62430 4
1. Meteorology. I. Rasmussen, Erik A. II. Turner, J. (John), 1953–
QC994.75 .P645 2003 551.55'13'0911–dc21 2002073925

ISBN 978-0-521-62430-5 Hardback

Cambridge University Press has no responsibility for the persistence or accuracy of URLs for external or third-party internet websites referred to in this publication, and does not guarantee that any content on such websites is, or will remain, accurate or appropriate.

© in this web service Cambridge University Press www.cambridge.org

CAMBRIDGE

Cambridge University Press
978-0-521-62430-5 - Polar Lows: Mesoscale Weather Systems in the Polar Regions
Edited by Erik A. Rasmussen and John Turner
Frontmatter
More information

Contents

© in this web service Cambridge University Press www.cambridge.org

CAMBRIDGE

Cambridge University Press
978-0-521-62430-5 - Polar Lows: Mesoscale Weather Systems in the Polar Regions
Edited by Erik A. Rasmussen and John Turner
Frontmatter
More information

© in this web service Cambridge University Press www.cambridge.org

CAMBRIDGE

Cambridge University Press
978-0-521-62430-5 - Polar Lows: Mesoscale Weather Systems in the Polar Regions
Edited by Erik A. Rasmussen and John Turner
Frontmatter
More information

Contributors

A. M. CARLETON
College of Earth and Mineral Sciences
The Pennsylvania State University
302 Walker Building
University Park
PA 16802-5011
USA

S. GRØNÅS
Allegt. 70
Geofysisk Institutt
University of Bergen
5007 Bergen
Norway

G. HEINEMANN
Meteorologisches Institut der Universität Bonn
Auf dem Hugel 20
53121 Bonn 1
Germany

K. NINOMIYA
Frontier Research System for Global Change
3173-25 Showamachi
Kanazawa-ku
Yokohama
236-0001
Japan

© in this web service Cambridge University Press www.cambridge.org

CAMBRIDGE

Cambridge University Press
978-0-521-62430-5 - Polar Lows: Mesoscale Weather Systems in the Polar Regions
Edited by Erik A. Rasmussen and John Turner
Frontmatter
More information

E. A. RASMUSSEN
Hoejbakkestraede 2
DK 2620 Albertslund
Denmark

E. RAUSTEIN
Allegt. 70
Geofysisk Institutt
University of Bergen
5007 Bergen
Norway

I. RENFREW
British Antarctic Survey
High Cross, Madingley Road
Cambridge
CB3 0ET
UK

B. RØSTING
Norwegian Meteorological Institute (DNMI)
P. O. Box 43
Blindern
N-0313 Oslo
Norway

J. TURNER
British Antarctic Survey
High Cross
Madingley Road
Cambridge
CB3 0ET
UK

A. VAN DELDEN
Institute for Marine and Atmospheric Sciences
Utrecht University
Princetonplein 5
3584 CC Utrecht
The Netherlands

© in this web service Cambridge University Press www.cambridge.org

CAMBRIDGE

Cambridge University Press
978-0-521-62430-5 - Polar Lows: Mesoscale Weather Systems in the Polar Regions
Edited by Erik A. Rasmussen and John Turner
Frontmatter
More information

Preface

Since the first detailed investigations of polar lows and other high latitude, mesoscale weather systems were carried out in the late 1960s there have been major advances in our knowledge regarding the nature of such systems and the mechanisms behind their formation and development. High resolution satellite imagery has shown how frequently such lows occur in both polar regions and has illustrated the very wide range of cloud signatures that these systems possess. Great strides have also been made in representing these weather systems in numerical models. With their small horizontal scale, it proved difficult to represent the lows in the early modelling experiments, but the new high resolution models with good parameterizations of physical processes have been able to replicate a number of important cases, despite the lack of data for use in the analysis process.

Although case studies of mesoscale lows have been undertaken for many years, recent research has been able to draw on many new forms of data, especially from instruments on the polar orbiting satellites. Scatterometers have provided fields of wind vectors over the ice-free ocean, passive microwave radiometers have allowed the investigation of the precipitation associated with the lows, and new processing schemes for satellite sounder data have given information on their three-dimensional thermal structure. In addition, aircraft flights through polar mesoscale lows have provided high resolution, three-dimensional data sets on the thermal and momentum fields. In recent years meteorologists have therefore had an unprecedented amount of data with which to conduct research into these important high latitude weather systems.

Although many research papers have been published on polar lows since the 1960s, a major advance in research into such systems was the publication of the book *Polar and Arctic Lows* in the late 1980s (Twitchell *et al.*, 1989). This volume came at the end of an intense period of research focused around the Norwegian Polar Lows Project, which had observational, climatological and modelling

© in this web service Cambridge University Press www.cambridge.org

CAMBRIDGE

Cambridge University Press
978-0-521-62430-5 - Polar Lows: Mesoscale Weather Systems in the Polar Regions
Edited by Erik A. Rasmussen and John Turner
Frontmatter
More information

elements, which were carried out in Europe and the USA. The book contained papers by a number of workers active in polar lows research and brought together many of the new research ideas that emerged during the 1980s. However, since that time there have been many advances in the study of polar lows and other mesoscale weather systems. Whereas most of the early research was concerned with the Arctic, during the 1990s there have been a number of studies of Antarctic weather systems, including aircraft investigations. There has also been a noticeable broadening of the investigations to include the whole spectrum of observed systems and not just the intense 'polar lows' that the early studies examined. Finally, recent investigations have often made use of both observational data and the output of numerical models, which has provided very comprehensive pictures of the vortices examined. This current volume therefore grew out of our desire to provide a comprehensive review of the mesoscale weather systems that are found in the two polar regions in light of the great deal of research that has been carried out over the last ten years.

The book has been written by a number experts in the field of high latitude mesoscale weather systems, many of whom are members of the European Geophysical Society's Polar Lows Working Group. This group is a focus for much of the polar lows research in Europe and includes scientists with interests in the modelling, observational and climatological aspects of the subject. In order to have the best possible coverage of the current research, the decision was taken to have a fairly large number of authors for the various chapters, but with considerable editing of the volume so that a coherent picture of the subject could be presented. Primary goals for the book were to try and integrate the theoretical and observational aspects of the subject and to bring together Arctic and Antarctic investigations. There is therefore extensive cross-referencing between the observational, modelling and theoretical sections where we have tried to point to well-observed examples of vortices that help to illustrate the presently understood theoretical background to the development and signatures of these lows. Of course there are still large gaps in our understanding of polar lows and there are frequent references to future research needs.

The book has been organized to reflect the different facets of research that are taking place. In the Introduction (Chapter 1) we provide details of the scope of the book and discuss the historical background to the subject and the bewildering variety of names used over the years to describe the phenomena observed. Chapter 2 deals with the climatological occurrence of the lows, based largely on satellite imagery. An important goal here was to try and relate the spatial and temporal variability of the lows with some of the major climatological cycles, such as the El Niño–Southern Oscillation and the North Atlantic Oscillation. Chapter 3 covers the observational investigations that have been

© in this web service Cambridge University Press www.cambridge.org

CAMBRIDGE

Cambridge University Press
978-0-521-62430-5 - Polar Lows: Mesoscale Weather Systems in the Polar Regions
Edited by Erik A. Rasmussen and John Turner
Frontmatter
More information

carried out and attempts to summarize this work into a picture of the underlying mechanisms that are responsible for the observed form of the vortices. Chapter 4 examines the various theoretical ideas that have been proposed to explain the observed weather systems. Where possible, pointers are provided to cases that seem to fit the theoretical models proposed. Within this chapter we have assumed that the reader is familiar with the fundamentals of dynamical meteorology and have therefore not dealt extensively with the basics of, for example, baroclinic instability. On the other hand, we have discussed new concepts, such as potential vorticity, in more detail as they relate to polar lows. Chapter 5 deals with recent numerical experiments that have attempted to simulate various cases in the Arctic and Antarctic. Chapter 6 examines the practical aspects of forecasting mesoscale lows using model output and observational data. In Chapter 7 we attempt to draw together work presented in the earlier chapters to assess our current understanding of high latitude mesoscale weather systems. We also compare the systems observed in the two polar regions and suggest possible topics for future research.

Many individuals and organizations have contributed to the preparation and production of this volume. The Satellite Receiving Station at the University of Dundee, Scotland provided many excellent satellite images illustrating polar lows in the Arctic. Professor David Bromwich (Byrd Polar Research Center, Ohio State University) provided a number of the Southern Hemisphere DMSP and AVHRR satellite images used in Chapters 1 and 2. A large number of the figures previously published in journals were scanned and optimized for publication by Jean Sinclair, Jayne Goodman and Mark Andrews while employed by the British Antarctic Survey. Many of the surface and upper-air charts used were redrawn by Mark Andrews and Nick McWilliam at the British Antarctic Survey. Izaak Santoe and Jaco Bergenhenegouwen drew several of the figures used in Chapter 4. Sander Tijm wrote the program which was used to illustrate hydrostatic adjustment to horizontally inhomogeneous heating in Chapter 4. Jens Rytter prepared the CAPE figures used in Chapter 4. Assistance was provided by Duane Carpenter, Chantal Claud, Mark Fitch, Kristina Katsaros, Lynn McMurdie, Nelly Mognard, and Yudong Song in the research presented in Section 2.1.

Finally, we would like to thank the many organizations and funding agencies that have supported the research presented here, including the US National Science Foundation (the work presented in Section 2.1 was funded by grants SES-86-03470, OPP-88-16912 and OPP-92-19446), the British Antarctic Survey, Natural Environment Research Council, UK, Climate System Research, University of Tokyo and the University of Copenhagen.

© in this web service Cambridge University Press www.cambridge.org