Numerical Weather and Climate Prediction

This textbook provides a comprehensive, yet accessible, treatment of weather and climate prediction, for graduate students, researchers, and professionals. It teaches the strengths, weaknesses, and best practices for the use of atmospheric models, and is ideal for the many scientists who use such models across a wide variety of applications. The book describes different numerical methods, data assimilation, ensemble methods, predictability, land-surface modeling, climate modeling and downscaling, computational fluid-dynamics models, experimental designs in model-based research, verification methods, operational prediction, and special applications such as air-quality modeling and flood prediction. The book is based on a course that the author has taught for over 30 years at the Pennsylvania State University and the University of Colorado, Boulder, and also benefits from his wide practical modeling experience at the US National Center for Atmospheric Research.

This volume will satisfy everyone who needs to know about atmospheric modeling for use in research or operations. It is ideal both as a textbook for a course on weather and climate prediction and as a reference text for researchers and professionals from a range of backgrounds: atmospheric science, meteorology, climatology, environmental science, geography, and geophysical fluid mechanics/dynamics.

Tom Warner was a Professor in the Department of Meteorology at the Pennsylvania State University before accepting his current joint appointment with the National Center for Atmospheric Research and the University of Colorado at Boulder. His career has involved teaching and research in numerical weather prediction and mesoscale meteorological processes. He has published on these and other subjects in numerous professional journals. His recent research and teaching has focussed on atmospheric processes, operational weather prediction, and arid-land meteorology. He is the author of *Desert Meteorology* (2004), also published by Cambridge University Press.

"Numerical Weather and Climate Prediction is an excellent book for those who want a comprehensive introduction to numerical modeling of the atmosphere and Earth system, whether their interest is in weather forecasting, climate modeling, or many other applications of numerical models. The book is comprehensive, well written, and contains clear and informative illustrations."

Dr. Richard A. Anthes, President,
University Corporation for Atmospheric Research, Boulder

"Tom Warner's book is a rich, effectively written and comprehensive detailed summary of the field of atmospheric modeling from local to global scales. It should be in the library of all meteorologists, climate researchers, and other scientists who are interested in the capabilities, strengths and weaknesses of modeling."

Professor Roger A. Pielke, Sr.,
Department of Atmospheric Science, Colorado State University, Fort Collins

"Tom Warner has taught Numerical Weather and Climate Prediction courses for over thirty years at Pennsylvania State University and the University of Colorado at Boulder. He also has been one of the principle developers of numerical models widely used in the atmospheric science community, and has a long history of applying such codes. This extensive background gives Professor Warner a unique insight into how models work, how to use them, where their problems lie, and how to explain all of this to students. His book assumes students have a basic understanding of atmospheric science. It covers all aspects of modeling one might expect, such as numerical techniques, but also some that might be unexpected such as ensemble modeling, initialization, and error growth. Today most students have become model users instead of model developers. Fewer and fewer peer into the models they use beyond the narrow regions that may directly interest them. With hundreds of thousands of lines of code, and groups of developers working on individual parts of the code, very few can say they truly understand all the parts of a model. Professor Warner's textbook should help both the student and the more advanced user of codes better appreciate and understand the numerical models that have come to dominate atmospheric science."

Professor Brian Toon, Chair,
Department of Atmospheric and Oceanic Sciences, University of Colorado, Boulder

"Tom's new book covers an impressive range of need-to-know material spanning traditional and cutting-edge atmospheric modeling topics. It should be required reading for all model users and aspiring model developers, and it will be a required text for my NWP students."

Professor David R. Stauffer,
Department of Meteorology, The Pennsylvania State University

"The book addresses many practical issues in modern numerical weather prediction. It is particularly suitable for the students and scientists who use numerical models for their research and applications. While there have already been a few excellent textbooks that provide fundamental theory of NWP, this book offers complementary materials, which is useful for understanding of key components of operational numerical weather forecasting."

Professor Zhaoxia Pu,
Department of Atmospheric Sciences, University of Utah

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THOMAS TOMKINS WARNER

National Center for Atmospheric Research, Boulder, Colorado

and

University of Colorado, Boulder

CAMBRIDGE
UNIVERSITY PRESS

CAMBRIDGE UNIVERSITY PRESS
Cambridge, New York, Melbourne, Madrid, Cape Town, Singapore,
São Paulo, Delhi, Dubai, Tokyo, Mexico City

Cambridge University Press
The Edinburgh Building, Cambridge CB2 8RU, UK

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

www.cambridge.org
Information on this title: www.cambridge.org/9780521513890

First published 2011

Printed in the United Kingdom at the University Press, Cambridge

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

Library of Congress Cataloging-in-Publication data
Warner, Thomas T.
Numerical weather and climate prediction / Thomas T. Warner.
p. cm.
Includes bibliographical references and index.
ISBN 978-0-521-51389-0 (hardback)
1. Weather forecasting – Mathematical models. 2. Climatology – Mathematical models. I. Title.
QC995.W27 2011
551.63′4 – dc22 2010035492

ISBN 978-0-521-51389-0 Hardback

Lewis Fry Richardson is arguably the father of numerical weather prediction. In addition to his great interest in methods for modeling the atmosphere, he was equally passionate about developing mathematical equations that could predict wars, with the hope that they could thus be avoided. Let us all, in small or large ways, follow LFR's passions.

With gratitude
to
John Hovermale,
who wanted to write this book