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Advancing Weather and Climate Science

Meteorology is a rapidly moving science. New developments in weather forecasting, climate science and observing techniques are happening all the time, as shown by the wealth of papers published in the various meteorological journals. Often these developments take many years to make it into academic textbooks, by which time the science itself has moved on. At the same time, the underpinning principles of atmospheric science are well understood but could be brought up to date in the light of the ever increasing volume of new and exciting observations and the underlying patterns of climate change that may affect so many aspects of weather and the climate system.

In this series, the Royal Meteorological Society, in conjunction with Wiley-Blackwell, is aiming to bring together both the underpinning principles and new developments in the science into a unified set of books suitable for undergraduate and postgraduate study as well as being a useful resource for the professional meteorologist or Earth system scientist. New developments in weather and climate sciences will be described together with a comprehensive survey of the underpinning principles, thoroughly updated for the 21st century. The series will build into a comprehensive teaching resource for the growing number of courses in weather and climate science at undergraduate and postgraduate level.

Series Editors

Peter Inness
University of Reading, UK

William Beasley
University of Oklahoma, USA
If you are interested in learning how weather forecasts are produced in today’s forecasting centres then this book aims to be a complete primer, covering the end-to-end process of forecast production. Other textbooks cover specific aspects of the process and, in particular, the formulation of numerical models, but here we aim to bring a description of all the relevant aspects together in a single volume, with plenty of explanation of some of the more complex issues and examples of current, state-of-the-art practices.

This book grew out of a module on ‘Operational Forecasting Systems and Applications’, which is part of the University of Reading MSc in Applied Meteorology. Because the University of Reading also runs an MSc course in Numerical Modelling of the Atmosphere and Oceans, and another in Data Assimilation, the module deliberately avoids too much detail on the mathematical formulation of numerical models and the statistical and numerical formulation of data assimilation schemes. This book follows the same approach and is intended to be an overview of the end-to-end process of weather forecast production at a major National Weather Service. The physics and numerics of models and the formulation of data assimilation schemes are touched upon in the module, but other options exist for students at Reading if they want to learn about these aspects in more detail. Because the students at Reading come from all around the world, the module also attempts to be as generic as possible when discussing operational weather forecasting. However, because of our location in the United Kingdom (with UK Met Office staff based in the University’s Meteorology Department) and with the European Centre for Medium-range Weather Forecasts (ECMWF) two miles down the road, many of the examples included in the module (and hence this book) are based on practices at these two major forecasting centres.

When I started to put together material for the MSc module in 2005, it soon became clear that there was no good single textbook available on the process of operational weather forecast production. There were several excellent texts on the numerical formulation of models and the design of data assimilation schemes, and several more have appeared since. The lack of books on operational weather forecasting is probably because this is a rapidly developing field, with a lot of variations in practices between different forecasting centres, making its operational application a difficult field to describe in a textbook. Another issue is that the people involved in
operational forecasting on a day-to-day basis are also far too busy doing their jobs to take time out and write a book about it all! I discovered this when, as series editor for this Wiley-Blackwell series on Advancing Weather and Climate Science, I started to approach potential authors for a textbook on this subject. Many people said that a textbook would be useful but they were unable to commit themselves to writing one.

I decided, therefore, that it would be worth trying to commit the material from the Reading MSc module, together with further detail and examples, to a book. Steve Dorling at the University of East Anglia, who teaches similar modules while also being Innovations Director at the UEA-based Weatherquest Ltd, a private-sector company, agreed to join me in this venture. We realised at the outset that we would have to accept that some aspects of the book would become out-of-date fairly rapidly, and that using specific examples of practices at one forecasting centre might also alienate potential readers with an interest in practices at a different centre. Despite this we agreed that it was worth trying to commit the current state of the art to a textbook and have tried to be as generic as possible when describing aspects of numerical model design and formulation. We hope the final product and any subsequent editions will be adopted by professional meteorological training colleges, by universities and indeed by individuals fascinated by meteorology.

This book then is aimed primarily at advanced undergraduate and masters level students of meteorology and so some knowledge of basic meteorology is assumed. Many universities around the world teach courses in theoretical meteorology and numerical modelling, using the many excellent books that are available covering these topics. Our book is aimed at helping the students on those courses to understand how the theory comes together in the day-to-day applications of weather forecast production. To some extent it could be regarded as an aid to converting from a student of meteorology into an operational practitioner. Discussions with staff in operational forecasting centres who are involved in the recruitment and training of new staff have commented that this would be a very useful purpose for a textbook. Many students leave university courses with an excellent grasp of the theory of meteorology but only a rather slim knowledge of the actual practice of forecast production.

This book is neither a manual on how to build a numerical model or how to be an operational weather forecaster but instead aims to cover the whole process of forecast production, from understanding the nature of the forecasting problem, gathering the observational data with which to initialise and verify forecasts, designing and building a model (or models) to advance those initial conditions forwards in time and then interpreting the model output and putting it into a form which is relevant to customers of weather forecasts. One subject which we wanted to include was the generation of
forecasts on the monthly-to-seasonal timescales. This has been an area of research for many years and some operational centres have been doing this type of forecasting for some time but again it is not well covered in textbooks.

As far as references are concerned we have taken a fairly sparse approach. When describing fundamentals of numerical weather prediction (NWP) model design we have referenced a very few seminal papers but other textbooks that cover this topic in more detail (such as Eugenia Kalnay’s excellent ‘Atmospheric Modeling, Data Assimilation and Predictability’) already provide extremely comprehensive reference lists in this area. We have included references when describing specific schemes, methods and techniques used at different operational forecasting centres, or particular studies conducted at these centres. However, because operational forecasting systems change rapidly and undergo frequent upgrades, many new developments never make it into the wider literature before they become out of date. The priority of operational centres is to maintain and develop their forecasting systems and update their internal documentation rather than publish their methods in the reviewed literature. Much of the detail of operational forecasting products in this book also comes from web sites which change regularly. We have provided web addresses where appropriate but the reader must be prepared for the information on those sites to change or for the addresses themselves to change or disappear.

Peter Inness

University of Reading
A number of forecasting centres have given us access to their documentation, training material and staff to help in the production of this book. In particular we would like to thank the European Centre for Medium-range Weather Forecasts (ECMWF) for a large amount of material from its excellent training courses which appears throughout the book. The UK Met Office has also provided a considerable amount of material and we would particularly like to thank Tim Hewson, a senior forecaster at the UK Met Office, for his guided tour around the National Meteorological Centre at Exeter and discussions on the role of a senior forecaster within a large forecasting organisation. The NOAA Climate Prediction Center and the online plotting and analysis facility of the NOAA Earth Systems Research Laboratory have also proved to be excellent sources of data and figures.

I would like to thank many colleagues at the University of Reading for interesting discussions on many aspects of theoretical and applied meteorology which have helped build the framework for this book. Thanks also to former colleagues at the Met Office College (1996–1999) with whom I worked training forecasters and meteorological research staff. The things I learnt whilst working there have been invaluable in many aspects of my current work. Thanks are also due to all the University of Reading students who have provided feedback on the MSc module ‘Operational Forecasting Systems and Applications’. Much of this feedback has been incorporated into this book – not least the suggestion that it ought to be written in the first place. Finally, thanks to my family who keep me from getting too absorbed in the work and help me relax and enjoy life.

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