Dynamics and Predictability of Large-Scale, High-Impact Weather and Climate Events

In recent years, a significant number of high-impact weather and extreme climate events have inflicted catastrophic property damage, and loss of human life, around the world, and hindered socio-economic development. Improving simulation and prediction of these events is an increasingly important requirement of public meteorological services.

Based largely on an International Commission on Dynamical Meteorology (ICDM) workshop, this timely volume covers a range of important research issues related to extreme events. Dynamical linkages between these extremes and various atmospheric and ocean phenomena are examined, including Atlantic Multi-decadal, North Atlantic, and Madden–Julian Oscillations, Annular Modes, tropical cyclones, and Asian monsoons. This book also examines the predictability of high-impact weather and extreme climate events on multiple time scales. Highlighting recent research and new advances in the field, this book enhances understanding of dynamical and physical processes associated with these events, to help managers and policy makers make informed decisions to manage risk and prevent or mitigate disasters. It also provides guidance on future research directions for experts and young scientists.

Written by leading researchers in weather and climate extremes, this comprehensive volume is ideal for professionals and policy makers working in disaster prevention and mitigation, and is a key resource for graduate students and academic researchers in atmospheric science, meteorology, climate science, and weather forecasting.

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Dynamics and Predictability of Large-Scale High-Impact Weather and Climate Events

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Preface

In recent years, a significant number of high-impact weather and climate events have inflicted catastrophic property damage and loss of human life, and hindered socio-economic development. Tropical cyclones are some of the most damaging weather systems; recent examples include hurricane Katrina in the USA in 2005 and hurricane Sandy in the USA in 2012, while multiple typhoons affected China in 2012. Severe flooding occurred in Australia in 2010–11, Europe in 2002, China in 2012, and Pakistan in 2010; there were droughts in China in 2010–2011, the USA in 2012; heat waves swept across the United States in 2012 and freezing rain in China in 2008. "High-impact" events encompass not only severe or extreme weather, but also other weather and climate events that have a major socio-economic impact. Thus, further improving weather forecasting and climate prediction capabilities are not only the topics at the forefront of the atmospheric science community, but also increasingly important requirements of public meteorological services. However, it is undeniable that there is a need for greater scientific knowledge to underpin weather forecasts and climate predictions, especially, for high-impact weather and climate events. The main outcome of this deficiency is a lack of knowledge of the dynamic mechanism and predictability of high-impact weather and climate events.

In view of this, the International Commission on Dynamical Meteorology (ICDM) held a workshop on the subject of "Dynamics and predictability of high-impact weather and climate events" on 6–9 August 2012, in Kunming, China. The ICDM is one of the commissions of the International Association of Meteorology and Atmospheric Sciences (IAMAS), which is in turn a constituent association of the International Union of Geodesy and Geophysics (IUGG). The commission is composed of international scientists who are committed to pursuing and cooperating in the science of dynamical meteorology. In the past, the ICDM has made very valuable contributions to the observation, research, analysis, and simulation of atmospheric dynamics across a range of time and space scales, and coupling of the atmosphere to the ocean. In turn those developments have led to improved skill in weather, climate, and environmental prediction for the benefit of society. The ICDM sponsors symposia that are held during the biennial IUGG General Assemblies and IAMAS Assemblies. The workshop was an additional event, intended to foster further understanding of the relevant dynamical and physical mechanisms that lead to extreme weather and climate events.

This book is largely based on the invited lectures presented at that workshop. It sets out our current understanding of the critical issues concerning dynamics and predictability of global and regional high-impact weather and climate events. Our aim is to summarize relevant newest advances in this field, and to enhance the understanding of physical processes associated with these events. The book covers a range of important research issues related to extreme events, including tropical cyclones, Asian monsoon, Madden–Julian oscillation, and annular modes, as well as the predictability of high-impact weather and climate events on multiple time scales. The combination of leading scientists and highly topical subject matter makes the book particularly appropriate for inclusion in the IUGG Special Publications series.

There have been a number of recent books describing high-impact or extreme weather and climate events. Many of these books describe extreme events with simple and vivid images to popularize the science, or they focus on the social and economic impacts of extreme events. However, this book focuses on the dynamics and predictability of extreme events, and assumes prior knowledge of the fundamentals of atmospheric dynamics. It may be the first comprehensive book dedicated to almost all key topics of extreme weather and climate events, with the main focus on synoptic and larger-scale phenomena. Our intention is not to create a geographical survey of extreme events, but rather to use specific examples to illustrate broader dynamical causes of such events. We anticipate that the book will become an important reference for these particular areas of atmospheric science.

This book is organized into six parts, comprising 27 peer-reviewed chapters. Part I, *Diagnostics and prediction of high-impact weather*, introduces the numerical prediction of high-impact weather, and discusses projected changes in climate extremes. Part II, *High-impact weather in mid latitudes*, discusses the relationship between variations in mid-latitude jet streams and severe weather events, troposphere–stratosphere interaction, and the use of probabilistic prediction techniques. Part III, *Tropical cyclones*, covers many aspects of the life-cycle of tropical cyclones and prediction of the associated severe weather. Part IV, *Heat waves and cold-air outbreaks*, analyses summer heat and drought and their relationship with both

large-scale dynamics and surface conditions. It also explores related mechanisms linked to cold-air outbreaks over Asia. Part V, *Ocean connections*, explores how the ocean contributes to extreme weather and climate events, with a primary focus on extended drought and wet periods. Part VI, *Asian monsoons*, surveys the prediction of extreme events associated with the Indian monsoon, and wider connections with East Asia, the Northwest Pacific, and links with annular modes.

The main authors for each chapter are leading scientists in the field of weather and climate extremes. The book comprises the most important content of the ICDM 2012 workshop, including contributions from the invited lecturers and other selected participants However, in order to produce a more balanced book, additional contributions were solicited from other leading researchers in the field.

The book is intended for graduate students and postdoctoral and other researchers who are interested in atmospheric dynamics and its relevance to the prediction of extreme events, across a range of time scales, from short-term weather forecasting to climate prediction. The book will provide a theoretical reference for improving researchers' understanding of the critical issues concerning the dynamics and predictability of global and regional high-impact weather and climate events. The improved understanding will also help relevant managers and policy makers to make proper decisions to manage risk and prevent or mitigate disasters.

We hope you enjoy reading this book.

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Majority of participants at noon, 6 August 2012 (photo: Tao LONG)

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