Hurricanes and Climate Change

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Editors

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Volume 3

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ISBN 978-3-319-47592-9 ISBN 978-3-319-47594-3 (eBook)
DOI 10.1007/978-3-319-47594-3

Library of Congress Control Number: 2017930220

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Printed on acid-free paper

This Springer imprint is published by Springer Nature
The registered company is Springer International Publishing AG
The registered company address is: Gewerbestrasse 11, 6330 Cham, Switzerland

Preface

This book was inspired by the 5th International Summit on Hurricanes and Climate Change, held in Chania, Greece, in June 2015. This ongoing series of conferences brings together leading experts from around the world to discuss work on the relationship between hurricanes, climate, and the assessment of hurricane risk. Hurricanes are among nature's most powerful and destructive phenomena. They have captured the interest of atmospheric researchers for more than 75 years, as before satellite observations became routinely available, they often struck with little or no warning. Tropical cyclones cause physical and economic disruption not only to societies in the tropics and subtropics but to the mid-latitude regions as well. Their destructive power comes not only from high winds and heavy rains but from storm surge and the potential to spawn tornadoes as they make landfall. The impacts of tropical cyclones fall most heavily on less developed nations, but developed nations have also suffered extreme hardship.

Early research established an understanding of the climatological and dynamic character of tropical cyclones, as well as their evolution and lifecycle. These advances led to an increase in forecast skill. The development of technologies, such as radar and satellite techniques, along with better monitoring methods, has led to a reduction in error for track and intensity forecasts. Additionally, studies have examined changes and variability in the occurrence of tropical cyclones. By understanding the interannual and interdecadal variability in tropical cyclone occurrence, societies can be better prepared and can position resources better for aiding impacted areas.

Today we understand that there is an intimate relationship and cooperation between atmospheric and oceanic conditions and processes leading to the development of tropical cyclones. Changes in climate will influence the occurrence and intensity of tropical cyclones in the future, even though the nature of these changes is not yet entirely clear. This book is comprised of ten chapters that present cutting-edge research which attempts to answer outstanding questions that remain in our understanding of tropical cyclones, whether this research endeavors to uncover their historical character, dynamics, societal impacts, and what the future may bring.

The first and second chapters discuss the climatological history of tropical cyclones. The first reviews research from the last decade in the subject of paleotempestology. This field endeavors to piece together the occurrence of tropical cyclones on the timescale of centuries and millennia or the climatological behavior of tropical cyclones before the observational record (about 160 years). These studies find that long-period behavior in the El Niño and Southern Oscillation phenomenon, the North Atlantic Oscillation, and location of the ITCZ are some factors that control periodicity on the century and millennial timescales. This work also reveals that tropical cyclone activity today is not at an historical high level going back to the mid-Holocene. The second chapter focuses on tropical cyclone landfalls along the southeast US coast, and the authors find that the locus of landfalls has shifted about 1° latitude further north. Thus, this study provides critical guidance for policy makers and those whose responsibility includes disaster preparedness.

The dynamic, thermodynamic, and kinematic behavior of tropical cyclones is another topic of wide interest, and Chaps. 3, 4, and 5 explore various aspects of tropical cyclone lifecycles. Chapter 3 examines the relationship between sea surface temperatures and tropical cyclone intensity in the eastern North Pacific, an area that has not been studied as extensively as other tropical cyclone basins. Using statistical methods, the authors find generally that sea surface temperatures exert a greater influence on tropical cyclone intensity than in other basins, in particular when compared with the North Atlantic.

The next chapter reviews both in situ and remote sensing methods that have been developed for estimating tropical cyclone winds. Better estimates will lead to better forecasts, which is of benefit to societies exposed to tropical cyclone risks. The authors note that each method has their strengths and weaknesses, but the use of different methodologies could, for example, lead to differing conclusions about trends in tropical storm intensity. They recommend the continued improvement of satellite-based techniques in order to improve the current state of the art.

The fifth study examines a new concept impacting tropical cyclone genesis over land called the “Brown Ocean.” In recent years, there have been a few notable cases of tropical cyclones intensifying over land. Conventional wisdom holds that these storms should decay once over land. However, if enough surface moisture is present, then tropical cyclones can actually strengthen over land if the latent heat flux is sufficient.

The techniques of risk management have become increasingly important in tropical cyclone studies, and the next chapter proposes a novel statistical analysis of tropical cyclone risk, both in the Atlantic basin and along the coast of China. The authors conclude that standard methods of risk assessment may underestimate tropical cyclone risk factors such as storm surge and wave height.

The topic of the final four chapters is the ability of models to project aspects of tropical cyclone occurrence on the timescales of decades or longer. Decadal projection of various phenomena in atmospheric science has been a topic of considerable interest in the last 5 years. The first of these chapters studies the use of the next generation general circulation models in assessing tropical cyclone risk in a warmer world. The authors propose that these models, with increased resolution,

will be able to reveal smaller-scale structures in future events, as well as provide the basis for the study of topics such as teleconnectivity between tropical cyclone basins and occurrence-to-landfall rates. The second of these chapters examines multidecadal simulations of tropical cyclone occurrences by basin. However, the authors also discuss the limitations of the models and tracking algorithms, the influence of model physics, and an overview of our current understanding and future direction of tropical cyclone activity research.

Forecasting the frequency of landfalling storms in the Atlantic basin on the seasonal and decadal timescales is the subject of the third modeling chapter. The authors use the UK Met Office's seasonal forecasting algorithm and demonstrate that there is significant skill in some regions due to the strong El Niño and Southern Oscillation signal, but lower skill in other places where this signal is not strong. The Met Office algorithm does produce successful multi-year forecasts of landfalling storms, and the authors point out that their methodology will identify decadal-scale active and inactive regimes for subregions within the Atlantic basin. The final chapter studies future changes in rainfall intensities associated with tropical cyclones, with a focus on landfalling storms. The authors performed a model sensitivity study to examine the relative impact of warmer sea surface temperatures only versus a doubling of atmospheric carbon dioxide concentration only and compare these to a control run. They found that tropical cyclone precipitation is more intense when sea surface temperatures increase. When atmospheric carbon dioxide concentration is doubled, tropical cyclone rainfall actually decreased slightly. Lastly, the study found that rainfall accompanying landfalling tropical cyclones increases and that the greater uplift of moist low-level air forced by landfall plays a significant role in increased vulnerability of coastal regions to tropical cyclone impacts.

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Acknowledgments

The authors would like to thank the expert reviewers for their time and careful review of the chapters. In addition, the authors are grateful for the assistance of Leilani Paxton and Amy Polen with this book, particularly with reference checking. We would like to acknowledge Rick Murnane who co-organized the 5th International Summit on Hurricanes and Climate Change with Jennifer M. Collins. This summit served as the inspiration of this book. Finally, the authors deeply appreciate the productive collaboration with the professionals at Springer, particularly Margaret Deignan and the copy-editing team.

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