Climate Dynamics: Why Does Climate Vary?

Introduction

Largely following the order the lectures were given in the graduate class, the book starts with the topic of moist convection in the tropics. Summarizing decades long research into a succinct article, Moncrief reviews the state of the art of understanding of the organized precipitating convective systems with an eye to improving the representation of such systems in global weather and climate models. Moncrief also address in this chapter the multi-scale convective organization in the Madden-Julian Oscillation- a major source of intraseasonal variability in the tropics. The second chapter proceeds to a prominent phenomenon on the seasonal time-scale: Monsoons. On covering this topic, Tim Li focuses his analysis on the Asian Monsoon and dissects the physical processes that are responsible for its intraseasonal and interannual variability. All three subcomponents of Asian Monsoon are covered here: the Indian Monsoon, the East Asian Monsoon, and the Western North Pacific Monsoon.

Chapter 3 through 6 move on to cover the El Nino Southern Oscillation (ENSO) Phenomenon—the dominant source for internanual variability in the climate system. Chapter 3 provides an introduction to this coupled ocean-atmosphere phenomenon, mostly from the observational perspective. In chapter 4, Penland shows how this apparently complex phenomenon can be well simulated by a linear stable, stochastic equation. With much of the ground-breaking work on the linear inversed modeling of ENSO being done by herself and her collaborators, Penland provides a complete and in-depth view of ENSO dynamics as seen within this conceptual framework. In chapter 5, Sun reviews the research on the diabatic and nonlinear aspects of ENSO—in particular the efforts leading to the "heat mixer" view of ENSO. The chapter underscores the intimate connection of ENSO with radiative heating—the existence of ENSO is not only due to the dynamical coupling between the atmosphere and ocean, but also due to the fact that the warmpool SST is sufficiently high relative to the temperature of the subsurface thermocline water. The chapter presents new evidence showing that the collective effect of ENSO events is to cool the warmpool and heat the subsurface thermocline water, reinforcing the notion that El Nino may acts a regulator of the tropical maximum SST. The chapter also provides a theoretical framework to understand how ENSO respond to global warming. In chapter 6, Captondi examines the simulation of ENSO in the state of the art models and remind readers of the continuing challenges to realistically capture the processes that are responsible for this natural model of climate variability.

Chapter 7, 8, and 9 bring the focus to the extratropics. In chapter 7, Alexander examines processes that influence North Pacific sea surface temperature including the Pacific Decadal Oscillation (PDO). The role of the surface ocean in integrating the stochastic forcing from weather events, the reemergence mechanism associated with

the seasonality, and the "atmospheric bridge" that connects the tropical Pacific with the extratropical regions, are all covered in this chapter. The chapter ends with a comprehensive analysis of the causes of PDO. In Chapter 9, Nakamura and his co-authors address the low frequency variability of the extratropical planetary waves. (It is these waves that cause the geographically-fixed longitudinal variations in the climate of the extratropics). The three-dimensional structure and dynamical characteristics of the north hemisphere climatological planetary waves are described and explained in this chapter, including their seasonal and geographical dependence. Nakamura et al also contrast the differences in these waves between the western and eastern hemispheres, and between the mid latitude ocean basins and continental regions. They also discuss the long-term changes in the planetary waves and the consequences of these changes on the predictability of the dominant modes of variability.

Chapter 9 moves to the polar regions. It deals with a polar climate phenomenon that has caused great concern from both scientists and the public: the melting of sea ice as revealed by the satellite observations. Find out in this chapter Holland's answer to the question whether the observed changes in sea ice is indicative of a tipping point behavior, leading to abrupt and irreversible changes.

The final chapter of the book addresses another topic that is of concern to both climate scientists and the public at large: are the tropical cyclones becoming stronger due to global warming? Chan, a veteran watcher of the tropical cyclones carefully reviews recent studies on the change of tropical cyclone (TC) activity in the western North Pacific and discusses how it might or might not be related to global warming. He reminds the readers here that the often emphasized thermodynamic conditions are just one of the factors that influence the intensity of the tropical cyclones. The dynamical conditions cannot be overlooked in understanding the observed changes in the statistics of the tropical cyclones and in predicting its future changes.

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