

**Can tropical cyclones be forecasted? Investigations in climatology and
numerical modeling**

Submitted for the

GENERAL EXAMINATION FOR THE DOCTORAL DEGREE

September 2006

Bradford S. Barrett

School of Meteorology

University of Oklahoma

Norman, OK 73072

Advisor: Dr. Lance M. Leslie

Abstract

Very recent advances in technological capacities, including high-resolution NWP models, advanced computing capabilities, improved instrumentation used to gather in-situ observational data, and enhanced satellite and radar remote-sensing techniques, have enabled the expansion of our theoretical understanding of TC structure and motion. However, we need only look to the very recent case of poorly forecasted Hurricane Ernesto (2006) to demonstrate that additional studies are needed to expand our understanding of TC structure and organization, particularly in the inner core. Thus, the purpose of this dissertation is to improve the ability to accurately predict TC structure, organization, intensity, and track.

This goal will be accomplished through three investigations. First, a climatological tool that quickly and succinctly displays the spread of historical TC tracks for any point in the Atlantic Ocean basin will be developed. This tool will be useful in all parts of the basin because it is derived from prior storm motion trajectories and summarily captures the historical synoptic and mesoscale steering patterns. It will display the strength of the climatological signal and allow for rapid qualitative comparison between the historical tracks and the more robust NWP models. Second, a new drag coefficient parameterization will be coded into a high-resolution mesoscale model to investigate the ability to predict TC mesoscale structure and, consequently, intensity and track. The primary energy source (sink) of a TC is the air-sea exchange of enthalpy (momentum), and the drag coefficient is critical in the mesoscale model's determination of this exchange. Until recently, the drag coefficient was thought to either

increase with increasing surface wind speed or remain constant. However, dropsonde measurements in eyewalls of TCs from 1997-2006 have shown that, in the very high-wind environment (greater than 33 m s^{-1}) of an intense TC, the drag coefficient actually decreases with increasing wind speed. The simulated TC's response to this new physical formulation is unknown, and thus will be investigated using a series of model sensitivity studies. Third, I will use a high-resolution mesoscale model to examine the interaction between the TC circulation and the island topography of the southern Windward Islands. Previous numerical studies of terrain impact have shown that TCs experience along-track accelerations, track deflections, intensity fluctuations, and altered precipitation patterns due to the interaction with island topography. However, these studies focused on Taiwan; the Greater Antilles of Hispaniola, Puerto Rico, and Cuba; and the Philippines; the Windward Islands of the eastern Caribbean have been largely neglected. Therefore, by varying the terrain representation in the mesoscale model, the important interaction between the TC circulation and these islands will be examined for the first time at high horizontal resolution. Collectively, these three investigations will provide answers to the main question of this dissertation, "can tropical cyclones be accurately forecasted?"