1. Introduction

A newly developed technique to simulate tropical disturbances known as point-downscaling (Nolan 2011) is employed to compare intensification (or lack thereof) in Tropical Storms Gabrielle (2001) and Edouard (2002). Point-downscaling uses modifications to the equations of motion such that high resolution models can maintain relatively constant vertical profiles of temperature, humidity, or wind across a large domain. This allows for a tropical cyclone in the model to be embedded in a homogenous environment making evolutionary analysis simpler. Simulations of Gabrielle and Edouard are performed using the Weather Research and Forecast (WRF) model in which various vertical profiles from each storm are prescribed using point-downscaling. This allows for insights into why Gabrielle intensified and Edouard did not, though the storms were in similar environments. We attempt to identify whether intensity differences are due to environmental factors such as adjacent dry air (for example) or if they are due to subtle differences in directional shear.

2. The Point-Downscaling Method

Nolan (2011) takes an alternative approach of resolving the convective scale and approximating the large scale environment using the method of point-downscaling (PDS). To maintain these nearly constant profiles throughout the simulations, small changes to the equations of motion in the WRF model are introduced. The main issue involves the necessity of wind shear without a compatible temperature gradient in a doubly periodic domain. For this reason an extra forcing term is added to the momentum equation to balance the pressure force that would be required if the temperature gradient were allowed to exist. This technique can be thought of as the Coriolis force acting only on the perturbation winds.

3. Model

The Weather Research and Forecast Model (WRF) version 3.3.1 was used for the simulations performed in this study. Doubly periodic boundary conditions were used for the outer grid with resolution of 18 km. Two vortex-following nested domains with resolutions of 6 and 2 km were centered on the storms in the simulations. Microphysical processes are simulated with the WRF 6 class microphysics scheme, which includes graupel (WSM6, Hong and Lim 2006). Surface fluxes, friction, and vertical mixing in the planetary boundary layer (PBL) are parameterized using the Yonsei University PBL scheme (YSU, Noh et al. 2003; Hong et al. 2006). The parameterizations for surface fluxes of heat, moisture and momentum for fluxes at high wind speeds follow Dudhia et al. (2008). The simulations depict TC development from a pre-existing, low-level vortex with peak tangential winds speed of 21 ms\(^{-1}\) at a radius of maximum winds of 90 km.

4. Results

Figure 1 shows the minimum central pressure for all 16 simulations performed in this study. The figure shows the “continuum” of development scenarios that arises by systematically varying the environments of the two storms. The naming convention (referred to in figure 1) for these simulations simply uses the first letter of the storm in a Therm-Winds-SST-RH ordering sense (i.e. The EGEG simulation contains SST and the thermodynamic profiles from the environment of Edouard and wind and relative humidity profiles from the environment of Gabrielle). Because the two storms were initialized with equal initial pressures, the authors can analyze the various hybrid storms and assign relative importance of environmental factors. Qualitative analysis of the 16 scenarios suggests that the thermodynamics and SSTs played the greatest role in determining how rapidly the storms deepened, with wind profiles playing the second greatest role.

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5. Conclusions and Future Work

The 16 simulations of Gabrielle and Edouard give the authors some insight into the developmental mechanisms of each storm. It appears that the thermodynamics (temperature, pressure, and specific humidity) played the strongest role in determining the rate of deepening of the storm. However, environmental winds do play a role in the strengthening (or weakening) of the two storms and play an important role in the distribution of deep convection. These results will be compared to observational analysis by Molinari (personal communication) which show little correlation between environmental helicity and TC intensity.

7. References


