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An evaluation of the Global Forecasting System (GFS) and Navy Operational Global Atmospheric Prediction System (NOGAPS) forecasting skill of tropical cyclogenesis

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1. Introduction

Tropical cyclone formation involves interaction of a variety of processes, both on the synoptic scale as well as the mesoscale. Gray (1968) identified several large-scale conditions as necessary for tropical cyclogenesis, including preexisting low-level relative vorticity and high mid-tropospheric humidity. Chen and Frank (1993) noted that mesoscale convective vortices (MCVs) spawned by tropical convection could be a possible mechanism for forming the initial low-level relative vorticity maximum. Ritchie and Holland (1997) noted several interactions between large-scale lower tropospheric circulations and mesoscale mid-level circulations during the formation of Typhoon Irving in 1992. Dickenson and Molinari (2002) examined the role of mixed Rossby-gravity waves in Western Pacific tropical cyclogenesis.

Each of these studies provides a mechanism for the formation of a low-level vorticity pre-cursor identified by Gray (1968). This variety of tropical cyclogenesis mechanisms provides a challenge in identifying the *sufficient* conditions for genesis. Tropical cyclogenesis also continues to be a forecasting challenge. Current operational models have difficulty accurately forecasting tropical cyclone formation. This is particularly true for the initial development stages of the pre-cursor tropical disturbance. Chen and Frank (1993) noted that the process by which MCVs evolved into tropical cyclones could be divided into two stages: the genesis stage (formation of mid-level mesoscale vortex) and the intensification stage (further intensification of this vortex into a tropical cyclone). The author has noted that the majority of tropical cyclogenesis studies have focused on the latter stage of development. Consequently, this study decided to focus on the genesis stage of tropical cyclone development.

The author examines the skill of the Global Forecast System (GFS) and the Navy Operational Global Atmospheric Prediction System (NOGAPS) in forecasting the genesis of the initial tropical disturbance. These two operational models are used extensively by the Tropical Prediction Center in forecasts of tropical cyclones that affect the United States. Hence, an accurate and objective assessment of tropical cyclogenesis forecast skill could be a valuable asset to both researchers and forecasters alike.

2. Data and Methodology

Forecasted fields of sea-level pressure, 850 hPa vorticity, and 150-300 hPa layer divergence are examined for Tropical Storm Bertha and Hurricane Isidore in the 2002 Atlantic hurricane season. In particular, 5-day, 4-day, 3-day, 2-day, and 1-day forecasts of these fields are generated for both the GFS and NOGAPS. The initial analysis of a low-pressure system by the Tropical Prediction Center (TPC) is taken as the time of cyclogenesis. In most cases, this initial analysis occurred several hours prior to classification as a tropical depression. The model forecasts are verified against the surface analyses produced by TPC. The author feels that cyclogenesis is primarily driven by near-surface processes; nevertheless 850 hPa vorticity is examined to account for systems that developed from the mid-troposphere downward. As a proxy for the favorability of upper-atmospheric conditions to cyclogenesis, 150-300 hPa layer mean divergence are examined. Forecasts of 850 hPa and 150-300 hPa divergence are verified against the corresponding satellite-derived analyses from the Cooperative Institute for Meteorological Satellite Studies.

The accuracy of a forecast for this study includes both spatial location and timing of the model-generated vortex. The low-pressure system must have developed within a six degree radius of the predicted location to be deemed an accurate forecast. This radius was calculated from the average distance that an easterly wave moves in a day. The forecasted trend in terms of location in also noted, to determine the forecast accuracy relative to the analysis as well as to each other. Consecutive forecasts of cyclogenesis events at different forecast periods are deemed successful, as opposed to cases where a model predicts cyclogenesis in a 5-day forecast, and then loses it until the 1-day forecast.

To better determine how successful the GFS and NOGAPS models are at anticipating tropical cyclogenesis, the percentage of successful forecasts of all tropical lows are examined for the

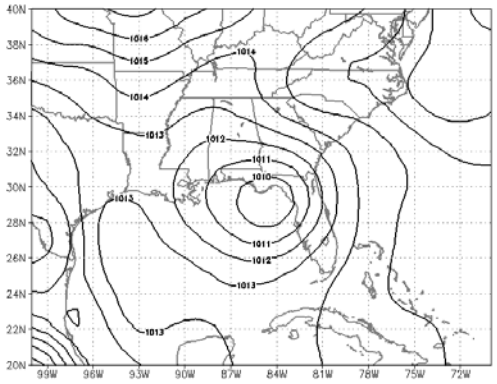

Figure 1.) GFS 72-hour forecast for the precursor to TS Bertha: initialized 00Z July 31 2002, valid 00Z August 3.

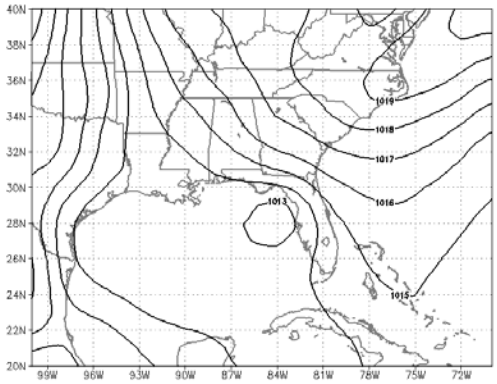

Figure 2.) NOGAPS 72-hour forecast for the precursor to TS Bertha: initialized 00Z July 31 2002, valid 00Z August 3.

2003 season. In this manner, the propensities of a model to either over-develop or under-develop tropical lows can be determined. In turn, the forecast skill of the models can be seen relative the models' ability to handle cyclogenesis events as a whole, regardless of further development of the low into a classified system.

3. Discussion

Preliminary analyses of Tropical Storm Bertha (Figures 1-2) show that both the GFS and NOGAPS anticipated development in the northeastern Gulf of Mexico. The GFS model has a much stronger vortex at 72 hours than the NOGAPS counterpart. By comparison, the TPC surface analysis (Figure 3) shows that the precursor low-pressure system developed slightly to the southwest, over the north-central Gulf of Mexico. Based on the parameters discussed above, both the GFS and NOGAPS models both successfully anticipated tropical cyclogenesis, at least for the 72-hour forecast. This examination

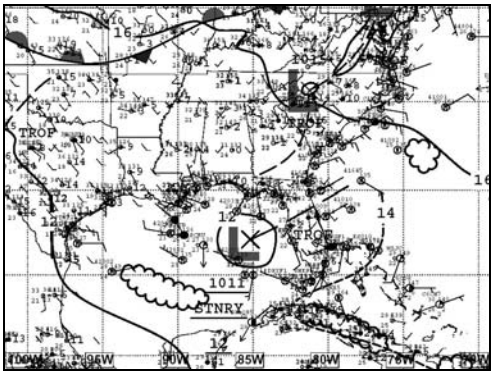

Figure 3.) TPC surface analysis at 00Z August 3, 2002.

will be extended for all forecast periods, as well as for Hurricane Isidore.

The preliminary analyses of tropical cyclogenesis forecast percentage for the 2003 hurricane season shows that, from June 1 though August 16, 32 model forecasts of tropical cyclogenesis verified, out of 126 total cyclogenesis forecasts for the GFS model. This analysis will be extended through the heart of the season, as well as for the NOGAPS model.

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