16c.3 A SEASON-LONG STUDY OF THE TROPICAL CYCLONE LIFECYCLES IN THE ATLANTIC BASIN (2001)

Ron McTaggart-Cowan* and Lance Bosart
University at Albany, State University of New York

1. INTRODUCTION

The goal of this study is to investigate the complete lifecycles of Atlantic tropical cyclones over a full season. Tropical cyclogenesis, tropical cyclone (TC) deepening mechanisms, hurricane-stage vortex motion, vortex spin-down, extratropical transition, and a multitude of other problems have been studied extensively in both diagnostic and modelling frameworks. Climatological and compositing studies have provided a wealth of information about environmental patterns and common structures involved in the generation, maintenance, and decay of TCs [e.g. Shapiro (1977)]. Idealized studies have explored the impacts of identifiable features and processes on the lifecycles of hurricane-like vortices [e.g. Willoughby (1988)]. Case studies have highlighted important mechanisms associated with the dynamics and physics of tropical systems and their interactions with the environmental flow [e.g. Bosart (2000)]. Building upon the findings of these studies, this work documents an investigation of the complete lifecycles of Atlantic TCs over the 2001 hurricane season.

2. OVERVIEW OF 2001 HURRICANE SEASON

The 2001 Atlantic hurricane season provides a broad spectrum of TC events (see Fig. 1 courtesy of the National Hurricane Center, NHC, and Table 1) including Cape Verde storms (Chantal, Erin, Felix), central Atlantic baroclinic developments (Lorenzo, Noel, Olga), and Gulf of Mexico hurricanes (Allison, Barry, Gabrielle). Five 2001 systems made landfall in North America, and several (including the damaging Michelle) impacted Central America and the Caribbean. Six of the TCs transitioned to extratropical systems, including Karen, which had previously undergone a tropical transition. Salient features of each of the TCs' lifecycles will be identified, and the storms classified and diagnosed according to the structures and mechanisms present at different stages of their evolutions.

As shown in the 2001 composite track map (Fig. 1), the TC genesis regions during the season were all located west of 30^{o}W, and occurred at latitudes from 10-30^{o}N. The hybrid stages of the storms were generally accompanied by erratic displacements, particularly notable for late-season Hurricane Olga (24 November - 4 December) after its formation in a non-tropical environment near 30^{o}N. A total of five storms were channeled into a track paralleling the eastern seaboard to the west of Bermuda during September of 2001 and passed through the boxed region of Fig. 1. Persistent troughing over the eastern half of the continent appears to have been responsible for generating a strong steering flow over this period. The influence of this troughing, accompanied by fluctuations in the strength of the Atlantic subtropical ridge will be investigated.

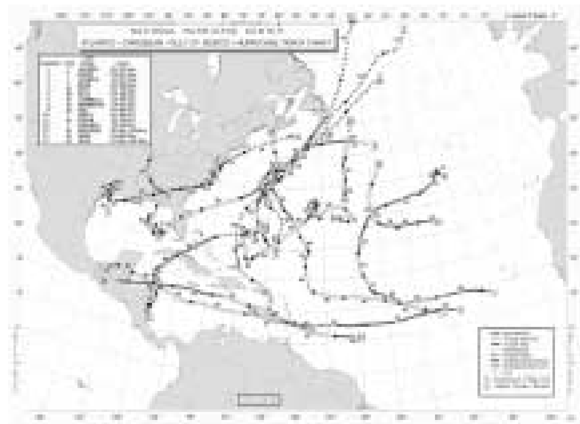

Figure 1: Atlantic TC track summary (NHC).

Despite reduced TC activity over the first half of the season (only four storms, none hurricanes, developed before the first of September), a surge in storm activity produced three genesis events in rapid succession in the first half of the month (Fig. 2). By the 11 September, Erin, Felix and Gabrielle were all active in the Atlantic basin. The clustering of the storms in the latter half of the season led to a greater degree of interaction between the storms, particularly during the genesis phase of newly-developing systems. As noted by the NHC in their storm summaries, the early stages of the lifecycles of many of the 2001 TCs was influenced by outflow from predecessor hurricanes. The importance of this outflow-genesis interaction will be another of the topics addressed in this study.

3. RESEARCH DIRECTIONS

As a first step towards the investigation of the season as a whole, the lifecycle of each TC is broken into several steps: genesis, tropical transitin, deepening, hurricane, spin-down, and extratropical transition. Not all storms will fall into each of these categories; however, investigation of each step will yield information about the degree of variability present within the 2001 storms. Of particular interest are any set of storms which displays common characteristics as well as any storm that departs greatly from the baseline set by the other members of the lifecycle stage.

Within each of the steps, further subdivisions are required in order to highlight important characteristics of a subset of the storms. The geographic and temporal distribution of the events serves as a guide in this respect. For example, the genesis stages of the three early-season Cape Verde storms can be contrasted with the five late-season, mid-Atlantic

**Corresponding author address*: Ron McTaggart-Cowan, ES-333, Dept. of Earth and Atmospheric Sc., Univ. at Albany, 1400 Washington Ave., Albany, NY, 12222, USA: e-mail: rmctc@atmos.albany.edu>

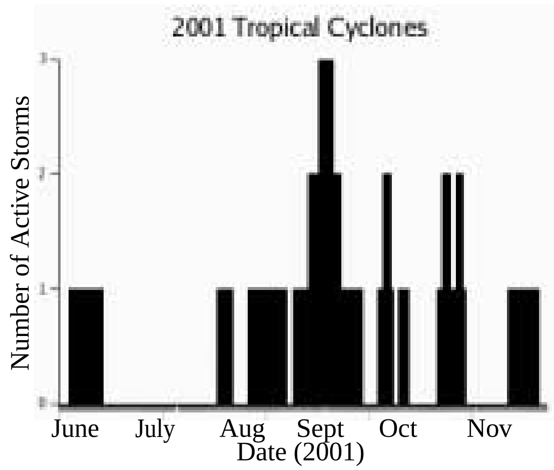

Figure 2: The number of active storms in the Atlantic basin of tropical depression status or greater.

developments in order to highlight both common features and dramatic differences in the genesis mechanisms. Likewise, a comparison of the processes involved in the tropical transitions of hurricanes Gabrielle, Karen and Olga, with the more traditional developments of the storms in the eastern Equatorial Atlantic, will aid in developing a set of typical characteristics for each mode of development. Especially in this component of the study, the influence of the environment on the TCs lifecycle is of primary importance.

An enhanced understanding of the importance to TC lifecycles of the environmental flow both in the tropics and at higher latitudes can be at least partially obtained through a full-season study. Evolving midlatitude regimes modulate tropical patterns, especially as the TCs accelerate northwards. By comparing standard teleconnection indicators, such as NAO and PNA patterns, during the stages of the TC lifecycles, larger-scale regimes which favor or suppress TC growth and activity may be identified.

Furthermore, consistent patterns such as the mid-September (2001) TC track off the Eastern Seaboard, provide an indication of strong TC-environment interactions. A study of anomaly patterns over the North American continent and the North Atlantic Ocean during the establishment and maintenance of this TC corridor may yield insight into the role of the environmental steering flow in determining the course of strong tropical vortices. As the skill of long-range forecasting of the planetary-scale flow continues to increase, links between phases of the major indices and the individual stages of the TC lifecycles could lead to improvements in the medium-range forecasting of Atlantic tropical storms.

Following the decomposition of the individual 2001 Atlantic TCs into their lifecycle stages and the analysis of each stage based on our current understanding of TC processes and dynamics, the task of reconstructing the season as a whole may be undertaken. Instead of describing the season as a series of isolated events, however, the reconstructed 2001 storm summary can be based on the characteristics and processes identified at each step of the TC lifecycle. Such a dynamically-based view of the season represents a unique tool with which to study the structures and processes at work during the evolution of the 2001 storms.

Once important characteristics have been identified in the reconstructed description of the season, common features may be used as a baseline for a set of simulations designed to develop a coherent, high resolution dataset for 2001 Atlantic TCs of particular interest. In conjunction with global analyses, these simulations will allow for a case-based investigation of the individual systems' lifecycles over a broad range of scales. Employing the diagnostic approaches and conceptual models of recent TC studies, such a description of 2001 Atlantic storms will provide further insight into the lifecycles of these severe weather events.

4. REFERENCES

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Table 1: Summary of 2001 Atlantic storms

Name	Dates	Intensity (ms^{-1})
Allison	5-15 Jun.	26 (TS)
Barry	2-7 Aug.	31 (TS)
Chantal	14-22 Aug.	31 (TS)
Dean	22-28 Aug.	31 (TS)
Erin	1-15 Sept.	54 (H3)
Felix	7-18 Sept.	51 (H3)
Gabrielle	11-19 Sept.	36 (H1)
Humberto	21-27 Sept.	46 (H2)
Iris	4-9 Oct.	66 (H4)
Jerry	6-8 Oct.	23 (TS)
Karen	12-15 Oct.	36 (H1)
Lorenzo	27-31 Oct.	18 (TS)
Michelle	29 Oct. - 5 Nov.	61 (H4)
Noel	4-6 Nov.	33 (H1)
Olga	24 Nov. - 4 Dec.	41 (H1)