P1.62 CLIMATOLOGICAL STUDY OF THE GULF STREAM'S IMPACT ON TROPICAL CYCLONE INTENSITY

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1. INTRODUCTION

Information on the effects of warm ocean currents such as the Gulf Stream (GS) on the intensity of tropical cyclones (TCs) is critical for forecasters and emergency management officials responsible for warning residents in the path of strengthening TCs close to the coast, particularly those that undergo rapid intensification. Shay et al. (2000) noted that sudden intensification often occurs while TCs pass over warm currents such as the GS, Florida Current, and Loop Current. These currents provide TCs with abundant heat since they contain much deeper and less stratified warm water. On the other hand, cold-core oceanic troughs and eddies may limit the growth of TCs (Xie et al. 1998). Although many studies have focused on how the current regime in the Gulf of Mexico may affect TC strength, none have focused exclusively on the role of the GS.

This study examines the intensity changes of selected TCs that passed over the GS off the Southeast Coast of the United States from 1944-1999. "Best track" data is used to determine the intensity changes of each TC before, over and after the GS. Thirty of the cases were classified as either intensifying or weakening based on specified criteria and each of these categories was investigated to determine if any storm-related parameters (intensity prior to the GS, type of track over the GS, and month of occurrence) were common in each group.

2. METHODOLOGY

The total and average hourly maximum wind speed (MWS) changes before, during, and after the GS were calculated for all 54 TCs, but the total and average hourly minimum central pressure (MCP) changes were calculated for just 33 cases since the MCP data in the HURDAT file was unavailable at certain times for 21 storms. The intensity changes before and after the GS were determined for the 6-h periods immediately prior to and after each TC passed over the GS; however, the length of time each storm spent over the GS varied from 6 to 60h with an average of 15h.

Twenty-two of the 30 TCs which had MCP and MWS data available were categorized as the intensifying cases since these storms experienced a net decrease in MCP over the GS and either a net increase or maintenance in MWS over the GS. The remaining eight TCs were classified as the weakening cases since all of these storms experienced a net increase in MCP and either a net decrease or maintenance in MWS while traversing the GS.

Each of the 30 TCs was examined further for their intensity just prior to the GS, type of track over the GS, and month of occurrence. The intensity prior to the GS was determined using the intensity data at the position immediately before each TC approached the GS. Parallel tracks were those in which the TC crossed the GS at an angle less than approximately 30°, where 90° was considered perpendicular to the general north-northeast flow of the GS. Thus, tracks were considered perpendicular if the angle between the TC track and the GS flow was greater than approximately 30°.

3. RESULTS

Table 1a and **Table 1b** summarize the percentages (and numbers) of TCs that intensified, maintained their strength, or weakened over the GS according to MCP and MWS, respectively. The intensity change trends are also given in both tables. Of the 23 TCs that intensified according to MCP, nine experienced net MCP falls over the GS, which had either been weakening or maintaining their intensity immediately prior to the GS. In addition, eight of the 14 storms that continued intensifying did so at either the same rate or a faster rate. Moreover, four of the five TCs that continued weakening did so at either a slower or the same rate, suggesting that the GS minimized the weakening of these storms. Similar results were obtained when MWS was examined (**Table 1b**). All seven of the storms that continued weakening did so at either a slower or equal rate.

3.1 Intensifying TCs

Of the 22 intensifying cases, 68% tracked parallel to the GS. It is believed that the more time a TC spends over the warmer waters of the GS the better the opportunity for the storm to be positively influenced. In addition, 16 of the 22 intensifying cases (73%) were Category 2 or weaker just prior to their passage over the GS. When normalized by the total number of storms that were Category 2 or weaker (34) and Category 3-5 (17), 68% of the weaker TCs intensified (displayed both a net MCP decrease and net MWS increase or a net MWS increase only) compared to 41% of the major TCs. Thus, it appears as though weaker TCs may be more likely than major hurricanes to be positively influenced by the GS.

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There also appears to be a seasonal preference for positive TC intensification over the GS. Nineteen of the 22 intensifying cases (86%) crossed the GS between August and October. However, 80% of the total TCs that occurred between May and July (5) intensified compared to 57% of those that occurred between August and October (46). Thus, even though there are typically less TCs early in the Atlantic season, those that do occur may be more likely to strengthen over the GS.

The numbers of TCs that rapidly, moderately, and slowly intensified over the GS according to MCP were also determined. Roughly half of the 23 TCs that intensified based on MCP moderately deepened (0.25mb/h DP/ Dt < 1.0mb/h) and eight of these storms tracked parallel to the GS. It should be noted that four of these storms rapidly deepened (DP/Dt 1.0mb/h) for at least a 6-h period over the GS, but they had moderate intensification rates overall. Nearly one-quarter (26%) of the TCs rapidly intensified, similar to extra-tropical "bombs" that undergo explosive development off the East Coast of the United States (Sanders and Gyakum 1980). The six rapid intensifiers include: Bertha '96, Bob '91, Hugo '89, Dora '64, Donna '60, and Helene '58, four of which occurred in September. Furthermore, three were already major hurricanes before crossing the GS and another was a strong Category 2 storm.

3.2 Weakening TCs

It was found that four of the eight weakening cases experienced net MCP changes of less than 4mb over the GS while undergoing no net MWS changes during the same period. All of the cases occurred between August and October and seven tracked perpendicular to the GS, spending less time over the warm current. There did not appear to be a preference for weakening based on previous intensity alone since four of the cases were Category 1 or weaker and the other four were major hurricanes.

4. CONCLUDING REMARKS

This preliminary study shows that the GS likely plays an important role in both enhancing as well as maintaining TC intensity. It was found that most of the coastal and landfalling TCs along the Southeast Coast of the United States from 1944 to 1999 that have been considered here either strengthened or maintained their intensity while passing over the GS. A majority of the TCs that were considered to have intensified generally tracked parallel to the GS, which increased the opportunity for TC-GS interaction. Also, most of the intensifying cases were found to be weaker storms within 6h of crossing the GS, possibly indicating an increased vulnerability of less intense TCs to the deeper warm waters of the GS.

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I 70 (23)			M 3 (1)	W 27 (9)			
C 61 (14)			S 39 (9)	C 56 (5)			S 44 (4)
S 43 (6)	E 21 (3)	F 36 (5)		S 60 (3)	E 20 (1)	F 20 (1)	

I 46 (25)			M 30 (16)	W 24 (13)			
C 64 (16)			S 36 (9)	C 54 (7)			S 46 (6)
S 44 (7)	E 31 (5)	F 25 (4)		S 57 (4)	E 43 (3)	F 0	

Table 1. **a) (left) Percentage of TCs (33 total) that either intensified (I), maintained their strength (M), or weakened (W) over the GS according to minimum central pressure (MCP). Also shown is whether the storms that intensified or weakened continued to (C) or started to (S) as well as whether the storms that continued to intensify or weaken did so at a slower rate (S), an equal rate (E), or faster rate (F). The numbers in parentheses represent the numbers of TCs in each category. b) (right) Same as a) except based on maximum wind speed (MWS) for all 54 TCs.**