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AN EXAMINATION OF THE QUALITY OF THE ATLANTIC TROPICAL CYCLONE DATABASE

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1. INTRODUCTION

Tropical cyclones affected segments of highly populated, economically sensitive coastlines and gained newsworthy prominence during 2004. During periods of heightened publicity, many media outlets made comparisons between present levels of landfall activity and events of the past. These comparisons for the Atlantic basin were based largely upon the climate records contained in the official "best track" dataset (Jarvenien et al. 1984). This dataset contains a record of all tropical cyclone activity in the Atlantic basin from 1851 to the present. It is known as the "best track" dataset because it uses all available surface, satellite, and aircraft reconnaissance observations – including those not accessible in real-time – to revise and refine the official post-storm estimate of tropical cyclone position and intensity (Neumann and Pelissier 1981). In addition to their role in identifying trends in activity, such climate records remain a potentially integral component in tropical cyclone track prediction (Bessafi et al. 2002). As Bessafi et al. point out, climatology (1) provides a reference frame from which to assess the performance of more advanced deterministic model predictions; (2) allows forecast uncertainty to be evaluated; (3) conveniently generates bogus tropical cyclone tracks; (4) provides a first-estimate forecast in the whole basin; and (5) provides a sensible forecast where departures from climatology and persistence are minor.

Because a climate record has many operational uses, and because predictions of future extreme weather events are made by extrapolating present trends, it is vital that the parent dataset be accurate, homogeneous, and subject to strict quality controls. However, as was mentioned by Buckley et al. (2003), such databases are subject to inconsistencies in the recorded levels of tropical cyclone activity, and these discrepancies are attributable to changes in observational platforms or operational classification schemes. Thus, we have recently begun a detailed analysis of the Atlantic basin record for this study. Ours preliminary results are contained in this preprint, and we will continue to build upon these findings and present our conclusions at the American Meteorological Society's 85th Annual Meeting.

2. TROPICAL CYCLONE CLIMATOLOGY IN THE ATLANTIC BASIN

For the Atlantic basin (including the North Atlantic Ocean, the Caribbean Sea, and the Gulf of Mexico), the most accurate period of record for tropical cyclone activity dates back to 1944 with the advent of aircraft reconnaissance. Since that time, several additional technological advances have led to an enhanced ability to observe tropical cyclones: the launch of the first weather satellites in the mid-1960s and the first geostationary satellites in the early 1970s; the use of a stepped-frequency microwave radiometer (SFMR) to measure near-surface wind speeds in the mid-1980s; the equipping of reconnaissance dropwindsondes with Global Positioning System (GPS) technology in the mid-1990s; the launch of QuickSCAT and Advanced Microwave Sounding Unit satellite sensors in the late 1990s; and the most recent 2003-2004 C-BLAST experimental synoptic surveillance flights and buoy deployments. These many technology upgrades potentially effected secular changes in the historical record of tropical cyclone activity, both in the number of cyclones detected and in the intensity classification of observed cyclones.

This historical record has been examined in detail by other authors (Landsea 1993 and 1999, Landsea et al. 1996 and 2000, and Henderson-Sellers et al. 1998). Landsea et al. (1999) found several important trends in the Atlantic basin tropical cyclone dataset. First, there

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are rather large interannual and interdecadal variations in the basin-wide occurrence of tropical cyclones. Specifically, they noted a "substantial" variation in the occurrence of hurricanes in the Caribbean Sea. Second, there is a degree of subjectivity involved in categorizing tropical cyclone intensity. Third, while there is "no significant trend" in the annual variability of tropical and subtropical storms, there does appear to be a pronounced multidecadal trend in the number of intense hurricanes that reach category 3, 4, or 5 on the Saffir-Simpson (Simpson 1974) intensity scale (Gray 1990 and Landsea 1993). Finally, the surface wind speeds of strong tropical cyclones from 1944 to 1969 may have been overestimated by 2.5 to 5 m s^{-1} (Landsea 1993). Landsea et al. concluded that the interannual variability of tropical cyclone frequency in the Atlantic basin shows "no significant trend" (1999).

3. TRENDS IN ATLANTIC BASIN TROPICAL CYCLONE ACTIVITY

As Landsea (2000) concludes, true variations in annual tropical cyclone activity may be masked by shifts in observational platforms or operational techniques during the period of record. Thus, this study compares the annual frequency of tropical storms, hurricanes, and intense hurricanes from 1944 to present and seeks to identify inhomogeneities resulting from non-meteorological changes in observational technology or operational techniques. It is commonly accepted that 1944 – when routine aircraft reconnaissance commenced – represents a significant break point in the dataset. This study searches for other statistically distinct frequency regimes that may be present in the most recent 60 years of the historical record.

Prior studies (Gray 1990, Landsea 1993, Landsea et al. 1996) have discovered significant multidecadal trends in the occurrence of major hurricanes. A time series of 5-year mean numbers of Atlantic tropical storms, hurricanes, and intense hurricanes from 1851 to present is presented in Figure 1. A comparison of major hurricane activity in the Atlantic basin from 1944-1961 and 1995-2003 is presented in Table 1. During the eighteen-year period from 1944 to 1961, sixty-three intense hurricanes developed in the Atlantic basin, and during the nine-year period from 1995 to 2003, thirty-two such tropical cyclones developed (Gray et al. 2003). Despite the remarkable similarity between intense hurricane activity during each period, it is interesting to note the great disparity between the numbers of *landfalling* intense hurricanes. From 1944 to 1961, sixteen intense hurricanes came ashore in Florida or on the U.S. east coast; however, only one intense hurricane (Fran in 1996) made landfall in this region from 1995 to 2003. This discrepancy in the number of landfalls raises several important questions about why these differences exist. For instance, are there significant synoptic differences between the periods? Is the dataset biased toward recording intense hurricane landfalls in the early period and against their

Table 1: Comparison of major hurricane activity in the Atlantic basin from 1944 – 1961 to 1995 – 2003 (from Gray et al. 2003).

	Number of Major Hurricanes (basin-wide)	Number of Major Hurricane Landfalls	
		Gulf Coast	Florida and East Coast
1944-1961 (18 years)	63	3	16
1995-2003 (9 years)	32	2	1
Annual Ratio of Difference (Earlier to Later Period)	0.98	0.75	8

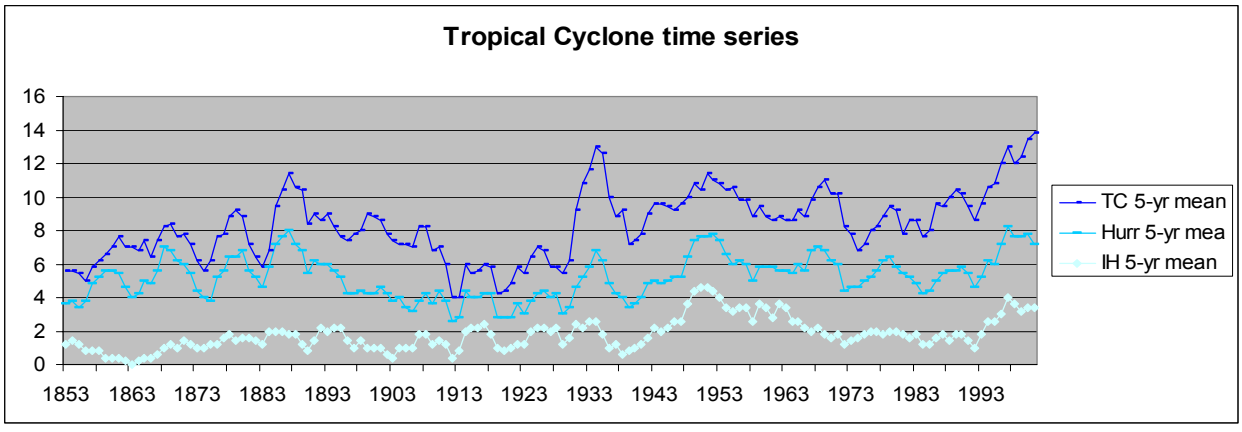

Figure 1: Time series of five-year mean numbers of Atlantic basin tropical storms (dark blue / top line), hurricanes (blue / middle line), and intense hurricanes (light blue / bottom line).

landfall in the later period? How does the possible lack of stationarity in the data from both meteorological factors and non-meteorological factors impact former and ongoing research? Gray et al. (2003) suggest the landfall discrepancy is due to the development and persistence of a mean long-wave trough over the eastern United States during the later nine-year period that was not present between 1944 and 1961. While this mean trough likely explains some of the disparity between landfall occurrences, changes in observational systems and operational schemes must be taken into account.

The mean annual number of tropical storms, hurricanes, and intense hurricanes for five different time periods from 1944-2003 is presented in Table 2. From 1944 to 1964, an average of 9.9 tropical storms, 6.2 hurricanes, and 3.5 intense hurricanes formed. From 1995 to 2003, similar heightened levels of tropical cyclone activity occurred, when an average of 12.9 tropical storms, 7.2 hurricanes, and 3.2 intense hurricanes occurred each year. Comparing the ratio of tropical storms to hurricanes and hurricanes to intense hurricanes, a smaller fraction of tropical storms became hurricanes from 1995-2003 than from 1944-1964 (0.63 to 0.55). One possible explanation for this discrepancy is that more tropical storms were detected and classified from 1995-2003 due to advances in observational technology. It is plausible to conclude that while few intense hurricanes likely went undetected in the Atlantic since 1944, rapid advances in satellite technology in the 1990s have led to the classification of two to three additional tropical cyclones during the period from 1995-2003 than from the earlier period from 1944-1964. By examining the ratio of intense hurricanes to tropical cyclones, we attempt to discount the possibility that purely meteorological factors led to this increase in overall tropical cyclone activity. Additional comparisons of Atlantic basin tropical cyclone activity will be presented at the American Meteorological Society 85th Annual Meeting.

4. CONCLUSIONS AND FUTURE WORK

The Atlantic basin "best track" database is a valuable resource that has been widely cited and continues to be used to identify climate trends. Prior studies (Landsea 1993, Gray 1990, Landsea et al. 1996) have pointed out significant multidecadal trends in the occurrence of major hurricanes. Other authors have examined the record of overall tropical cyclone activity in the Atlantic basin and concluded that while substantial interannual variability exists, no discernable trends can be identified. Henderson-Sellers et al. (1998) attribute this lack of identification to the relatively short period of accurate record (60 years).

This study examined discontinuities in overall tropical cyclone activity. Break points were identified, closely inspected, and compared against a timeline of technological and operational changes. It was found that a smaller fraction of tropical cyclones became hurricanes from 1995-2003 than from 1944-1964 (0.63 to 0.55). One possible explanation for this discrepancy is that more tropical storms are being detected because of the advances in observational technology.

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Table 2: Mean annual number of Atlantic basin tropical storms, hurricanes, and intense hurricanes for five periods from 1944 to 2003.

Period of Record	Mean annual occurrence of:			Ratio of:		
	Tropical Storms (TS)	Hurricanes (H)	Intense Hurricanes (IH)	H : TS	IH : H	IH : TS
1944-1964	9.9	6.2	3.5	0.63	0.56	0.35
1965-1974	9.0	5.6	1.6	0.62	0.29	0.18
1975-1984	8.4	5.4	1.8	0.64	0.33	0.21
1985-1994	9.0	5.0	1.4	0.56	0.28	0.16
1995-2003	12.9	7.2	3.2	0.56	0.44	0.25

previously published, as it provides the foundation for this study.

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