

Atlantic Hurricanes in the Second Half of the Nineteenth Century



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ABSTRACT

A historical revision of Atlantic tropical cyclones for the period 1851–90 is presented. This work was undertaken with the aim of improving knowledge of the tropical storms and hurricanes in the North Atlantic basin, which occurred during the latter half of the nineteenth century. Another aim of the study was to develop more reliable figures regarding cyclone frequency variations than those that were currently available. The 40-yr period covered by this study spans the 20 yr (1851–70) prior to the founding of a U.S. meteorological service as part of the U.S. Signal Service and the approximately 20 yr (1871–90) that military personnel of that service took care of the official meteorological affairs in the country, prior to the establishment of a civilian U.S. Weather Bureau within the U.S. Department of Agriculture. The period 1851–90 was found to be particularly attractive from a research standpoint because it covered the time elapsed from 1855, the last year included in the storm catalog prepared by Poey, which is used in the cyclone list shown by Tannehill, to 1878, the year the Signal Service began to systematically trace all West Indian hurricanes.

A comparison of hurricane activity, in terms of the total number of storms, is made between the 40-yr period of 1851–90, and the corresponding period in the twentieth century. Even after taking into account the large differences in the observational network during these two periods, a century apart, there is some suggestion that the earlier period was relatively less active.

1. Introduction

This paper presents the results of a 2-yr effort to improve the available information regarding frequency and intensities of North Atlantic and Caribbean hurricanes prior to the establishment of a modern tropical cyclone monitoring and detection system. Our study has focused on the identification and documentation of hurricane cases occurring during the second half of the nineteenth century and has led to a revision of Atlantic tropical cyclone history for the period 1851–90. Although we feel that a substantial amount of information exists for some hurricanes and tropical storms prior to the 1850s, the information is largely of a sketchy nature and not likely to be useful to the same degree as that of the second half of the nineteenth century.

We have identified many tropical storms and hurricanes that had not been previously documented; details can be found in a series of formal reports (Fernández-Partagás and Diaz 1995a,b, 1996), which are available from the authors. The new information is being used to update the hurricane track data compiled by Neumann et al. (1987, 1993). The new storm data has been described in detailed summary reports, which are available through the Tropical Prediction Center/National Hurricane Center of NOAA in Miami, Florida, and the Environmental Research Laboratory's Climate Diagnostics Center in Boulder, Colorado.

One goal of this study was to help quantify the historical or long-term vulnerability to tropical cyclones in the western Atlantic and greater Caribbean region. In addition, it was hoped the study would add to our understanding about the longer-term natural variability of tropical cyclone occurrence, physical characteristics, and threat. Such information and perspective would be particularly useful for applications by meteorologists, government, and other civic officials; disaster emergency managers; and resource specialists.

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2. Sources and methods

For the period 1851–70, the major sources for studying these storms were the tropical cyclone lists already available from several authors (Garriott 1900; Alexander 1902; Sarasola 1928; Tannehill 1938; García-Bonnely 1958; Dunn and Miller 1960; Ludlum 1963; Salivia 1972), miscellaneous books and articles (Rodríguez-Ferrer 1876; Viñes 1877, 1895; Frankenfield 1917; Chapel 1927; Martínez-Fortún 1942; Rodríguez-Demorizi 1958; Sullivan 1986), and the general news and marine intelligence published in newspapers, primarily in the *New York Times* and its predecessor the *New York Daily Times* and in the *Times* (London). For the period 1871–90, Neumann et al. (1993) became a major source of information and the storm tracks in that publication were checked against information from other sources, including most of the lists above, some books and articles already mentioned, and some additional ones (Mitchell 1924; Tucker 1982; Barnes 1995), as well as the marine intelligence and the general news published in newspapers, together with the *Monthly Weather Review*, which the U.S. Signal Service began publishing in 1872 (see Whitnah 1961).

For tropical cyclones that came close enough to land for their effects to be felt in populated areas, written accounts about storm impacts, and such weather observations as were being made in those areas at the time, would become an important source of storm information, which would find its way to newspapers and other types of reporting sources. Ship observations also represented a major source of information with regard to location and strength of these storms, and of course, they were the only source of information about storms occurring over the open ocean. By comparison, the weather monitoring system in place today includes not only these two traditional sources of information about major weather phenomena, such as tropical storms, but also satellite imagery, radar observations, aircraft reconnaissance, and other modern observation platforms, such as ocean buoys, that provide nearly constant surveillance and accurate meteorological measurements to national weather services.

All of the sources mentioned earlier were used in investigating storm cases that were already known and in documenting the existence and evolution of new ones; for the latter cases information contained in newspapers and in the *Monthly Weather Review* was found to be the most useful. We note that only

calendar months for the nominal hurricane season (June–October) were considered in this study, as the time and effort needed to review the historical information for the cool-season months was not deemed worthy of the potentially few additional storm numbers. Each case was treated separately and a write-up, which included the encountered information and a discussion, was prepared for each storm. To be consistent with Neumann et al. (1993), no formal classification of cyclones as tropical storms and hurricanes is given until 1886; however, some informal comments about the storm intensity were frequently included in the storm summaries. An example of the information included in the individual storm write-ups is presented below. The storm case presented here is for Storm 1, 1875 and is excerpted from Fernández-Partagás and Diaz (1995b). The track of this storm is displayed in Fig. 1 (bold track), together with the available tracks for the other tropical storms during that season. The case was not chosen for any special reason, but merely for the purpose of illustrating the type of materials that were prepared for each storm, regardless of it being an already known or a new case.

Storm 1, 1875 (16–19 August)

This is a new storm that the authors have documented on the basis of the following information:

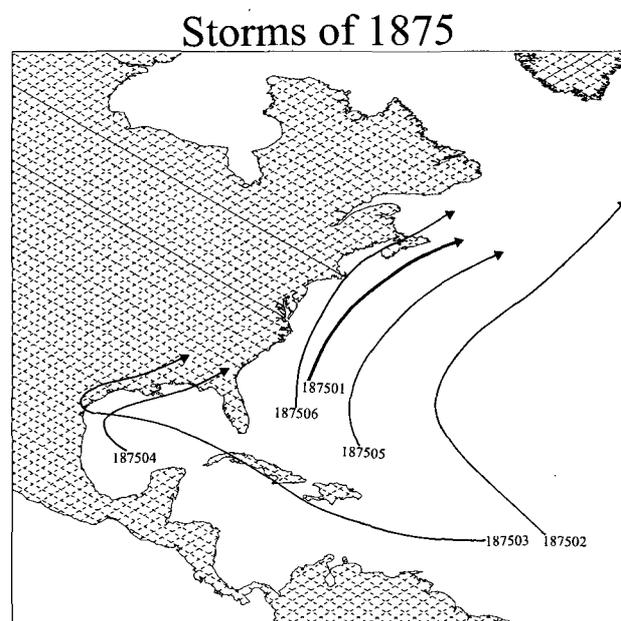


FIG. 1. Tropical cyclone tracks for the year 1875. Storm 1, described in the text, is shown in bold.

1) Schr. "J. W. Coffin", from Matanzas for New York, put into Charleston on Aug. 19, leaking badly. She reported having had very heavy weather (The New York Times, Aug. 21, 1875, p. 8, col. 6). 2) Ship "Anegor" (from Calcutta, May 4). Aug. 17, wind S., blowing a hurricane; lost fore and main lower topsails (The New York Times, Aug. 22, 1875, p. 12, col. 6). 3) Philadelphia, Aug. 23. Steamship "Illinois". Aug. 21, lat. 40 26 N., long. 69 W., spoke bark "Svanon", from Baltimore to Queenstown, reporting having experienced a hurricane on Aug. 17. which threw her on beam ends. The "Svanon" was then heading to Newport or Boston for repairs (The New York Times, Aug. 24, 1875, P. 8, col. 6 and 7). 4) Bark "Charles L. Leary" (from Liverpool in 25 days). Aug. 19, off Halifax, got the last of a hurricane, blowing S.E. to N.W. for 4 hours (The New York Times, Aug. 26, 1875, p. 8, col. 6). ["Last of a hurricane," is a vague statement.] 5) Boston, Aug. 26. Barkentine "Sarah", from Baddeck, C.B. for New York, put in for repairs. Aug. 19, lat. 42 10 N., long. 64 30 W., in a hurricane, lost foremasthead and main topmast (The New York Times, Aug. 27, 1875, p. 8, col. 5 and 6). 6) Bark "Oscar I." Aug. 20, lat. 42 43 N., long. 64 37 W., spoke bark "Sarah" steering W.S.W. with foremast and main top gallant mast gone (The New York Times, Aug. 27, 1875, p. 8, col. 5 and 6). 7) Bark "Electra" (from Sydney, C.B. in 16 days). Aug. 20, lat. 42 24 N., long. 64 23 W., had a violent gale from S.E. veering around to N.W., lasting 6 hours (The New York Times, Aug. 27, 1875, p. 8, col. 5 and 6). [This seems to be an erroneous report because the day and the position given by the "Electra" do not appear to fit well a Sydney, C.B.-New York sailing in 16 days.]

The authors have prepared the track shown in Fig. 5 (of the original report). However, the confidence placed in such a track is not high, and we believe that quite large errors are likely for the estimated 0700 LT positions. These positions, which took into account the information in items 1)–6) were as follows: 16 August, 32.3°N, 73.5°W; 17 August 35.7°N, 71.3°W; 18 August, 39.5°N, 68.0°W; 19 August 42.5°N, 64.0°W.

The storm seems to have attained hurricane status for at least a portion of its known lifespan.

For each year, cases were chronologically arranged according to their first day of detection. For example,

the third storm found for 1852 was denoted as Storm 3, 1852. For the period 1851–70, tracks were achieved for a large number of cases, provided that information was available for more than one location and time; a track could not be determined otherwise. Tracks are, of course, less accurate than the ones available for today's storms and they are envisioned as depicting the general motion of the storms from one area to another rather than the actual path followed by the storm center. The 0700 EST positions that are given along the tracks might have errors of 200–400 km or more, particularly over the open ocean. Tracks were plotted on maps for individual years; storm locations were also plotted by using a cross for those cyclones for which no track was achieved. Black dots along tracks were used for denoting 0700 LT positions and corresponding dates were indicated nearby. Large numbers near the beginning of the tracks and near crosses were used to indicate storm numbers in accordance to their first detection date throughout the year. Maps and other materials (including individual storm write-ups) pertaining to storms for the period 1851–80 are given in a series of reports by Fernández-Partagás and Diaz (1995a,b).

For the period 1871–90, the same general methodology used for the previous 20 yr was implemented, except that, as tracks existed for each already known storm (Neumann et al. 1993), such tracks were checked against information from other sources and corrected, extended, or otherwise modified when they failed to conform with available data or room for track improvement was found on the basis of such data. For this period, a number of new cases were documented. In addition, some possible cases for which documentation as tropical cyclones could not be clearly achieved on the basis of available data are discussed in the summary reports for 1886–90. Yearly maps containing modified and unmodified tracks, and tracks for new storms (not in Neumann et al. 1993), as well as storm write-ups, for the period 1881–90 can be found in Fernández-Partagás and Diaz (1996).

3. Synopsis of Atlantic tropical cyclones, 1851–90

Decadal totals of the number of storms of a tropical nature in the Atlantic Ocean over the period 1851–90 are presented in Table 1. The total number of storms for this 40-yr period is 298, an increase of 105 (nearly 55%) over previously published figures. The

TABLE 1. Summary list of tropical cyclones for the period 1851–90.

Period	Number of known storms		
	Before this study*	New storms this study	Current (updated) totals
1851–60	33	31	64
1861–70	25	51	76
1871–80	65	11	76
1881–90	70	12	82
Totals (1851–90)	193	105	298

* This column represents the storm totals found in Neumann et al. (1993), starting in 1871, and the totals from all the available lists, as referenced in the text, for the previous 20 yr.

revised storm totals for the 40-yr period yield an average frequency of about 7.5 storms yr⁻¹. The new storms are not evenly distributed over the 40-yr period, with 82 of them occurring in the period 1851–70 and only 23 in the period 1871–90. Figure 2 displays the number of known storms each year before and after the results of this study. The maximum number of new storms contributed for a single year was seven in 1870; no storm additions were possible

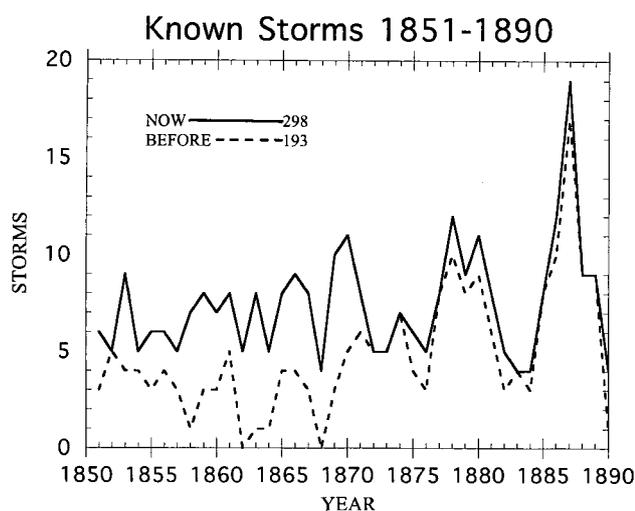


FIG. 2. Tropical storm totals, 1851–90, before (dashed line) and after (solid line) this study.

in 1852, 1872–74, 1877, 1883, 1885, 1888, and 1889. Prior to this study, the maximum and minimum numbers of storms in a given year were 17 in 1887, and 0 in 1862 and 1868, respectively. The corresponding numbers following the present study are 19 (1887) and 4 (1868, 1883, 1884, 1890). It should be mentioned that the 19 storm cases encountered for 1887 (Fig. 3) set a record for the second half of the nineteenth century that lasted until 1933, when 21 tropical storms and hurricanes formed (Neumann et al. 1993). Besides the 1933 season, the level of tropical storm activity of the 1887 season has been matched in the twentieth century only during the 1995 season.

The frequency distribution at decadal timescales does not exhibit very large differences in storm activity (Table 1). The resulting decadal totals largely eliminate the spuriously large increase in storm frequency that was present prior to this study. Even now, due to the greater lack of information available for the earlier years, it is more likely that storms may have escaped detection in the earlier decades than in the later ones. It is conceivable then, that the lesser number of storms in the 1850s, compared to the subsequent three decades may not be real.

Despite the likely undercount of tropical storms in the Atlantic, especially for storms that did not come close to land areas, the relative percentages of landfalling to total number of storms in two 40-yr periods, a century apart, is revealing (Table 2). The count of landfalling storms is likely to be relatively more accurate in the 1800s than the corresponding seasonal storm count. Evidence in support of this premise is provided in Fig. 4, which shows contour lines of the ratio of storm totals in the recent 40-yr period relative to the corresponding totals in the earlier period. Note that the ratios of the number of storms in the 1900s to that of the 1800s are close to unity in the western areas near to the landmasses, compared to the ratios evident over the open ocean regions. Assuming then that the ratio of landfalling storms (defined here as a storm where the established track intersected a land boundary anywhere in the region) to the total number of storms over a period of several decades is fairly constant, we estimate the actual total of Atlantic storms in the second half of the nineteenth century is approximately 335 (173/0.52). An analogous estimate of annual average storm frequency for each 40-yr interval is given in Table 2. This suggests that the recent 40-yr period may have produced more storms (about one additional storm per year) than an equivalent period a century ago.

Over the period 1851–70, it was possible to obtain a track for 91 out of the 140 storms that were encountered. Because only a few tracks for well-known storms had been derived before, the additional storm track information developed in this study is of great interest: tracks have been achieved for 65% of the presently known storms for the above mentioned period. Figure 5a shows the number of storms by year in comparison with the number of tracks achieved for the period 1851–70. Neumann et al. (1993) begin showing tracks on a regular basis in 1871. Therefore, for this time the focus of this study was shifted more toward independently checking those tracks for consistency with the available information, while at the same time continuing the search for storms that were, for whatever reason, not included in their compilation. Table 1 shows that 23 new storms were documented for the period 1871–90. However, on the basis of information contained in independent sources, it was found that a significant number of storms—82 out of the 135 storms, or 61%—of the tracks given in Neumann et al. (1993) for this same period needed to be modified in some manner, ranging from a simple adjustment in the timing along a small portion of the track to the total reconstruction of it. The year for which the most new tracks were obtained was 1870, with track information for 8 out of the 11 storms that were found for that

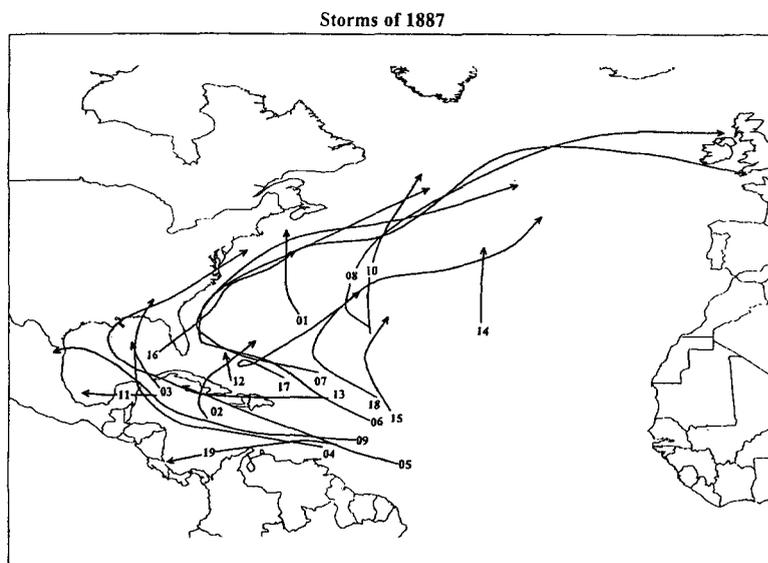


FIG. 3. Hurricane tracks for the active Atlantic hurricane season of 1887.

year. Each new storm was given a “best estimate” track, based on all the available information. In a few cases only a single set of geographical coordinates was possible. The minimum number of tracks for a single year occurred in 1851, with only two tracks achieved. We emphasize again that these tracks are much less accurate than the ones obtained for today’s storms and that errors of 200–400 km or more might be common along the tracks, particularly over the open ocean. In most cases, the achieved track is believed to have depicted the general motion of the storm from one area to another rather than the actual motion of the storm center itself.

Figure 5b compares the number of previously known storms that underwent some track modification based on the information gathered here. Note that the maximum number of modified tracks was 12 in 1887, with no tracks modified in 1890.

Figure 6 (top graph) displays the full set of tracks now available for the period 1851–90. The total set of tracks for the 1951–90 period is also shown (bottom of Fig. 6) for comparison. The general location of storm activity in the two periods is similar, albeit, clearly in a reduced fashion for the nineteenth century. An answer to the important question regarding possible changes in tropical storm activity that may accompany global climate change appears to only be hinted at in the present study. Because of the cruder system of communications and much smaller population densities 100 yr ago, it is not possible to say with certainty that the recent period is relatively more

TABLE 2. Comparison of relative frequencies of landfalling and total Atlantic tropical storms for two 40-yr periods: 1851–90 and 1951–90. Storm totals for the recent 40 yr are based on the best storm-track digital dataset, based on the atlas of Neumann et al. (1993).

Period	Landfalling storms	Total number of storms	Landfalling percentage
1851–90	173	298	58
1951–90	201	388	52
Average number of storms per year			
1851–90 (observed)	1851–90 (estimated)	1951–90	
7.5	8.5	9.7	

Ratio of Storm Frequency: (1951-90)/(1851-90)

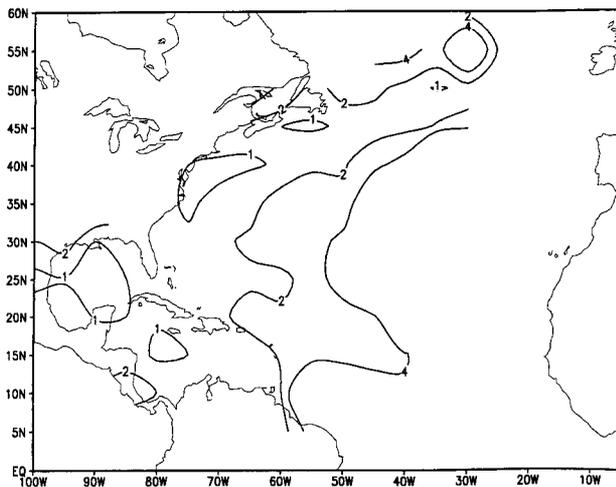


FIG. 4. Contour plot of the ratio of documented storms in the North Atlantic within 5° squares: (1951-90)/(1851-90).

active. We believe it is important to continue this effort in order to improve the estimates of tropical storm activity at a time when global surface temperature was about 0.5°C cooler than at present.

4. Concluding remarks

A significant number of new tropical cyclones in the western North Atlantic Ocean and greater Carib-

bean region has been documented in this study. An additional 82 storms have been identified for the period 1851-70, nearly 2.5 times the previous number of known tropical storm systems. For the 30-yr period 1851-80, 93 storms have been added to the list of 123 previously documented storms for this period, a 76% increase. For the 30-yr interval 1861-90, a total of 234 storms have now been identified. The 216 and 234 presently known tropical storms for these two overlapping 30-yr periods at the end of the nineteenth century compares with a modern total of 292 and 290 storms for the 1951-80 and 1961-90 periods, respectively. The totals in the nineteenth century are still likely to be a significant underestimate of the actual storm totals for this time, due to the much poorer system of communication and sparser population of that time, as well as to the obvious lack of modern observational tools, such as satellite and aircraft reconnaissance. However, this work has uncovered a significant number of new tropical cyclones, with values that now begin to approach the frequencies observed after World War II and much closer to the values that have been obtained for the decades immediately following the 1890s.

The use of information contained in tropical cyclone lists, miscellaneous books and articles on the subject, newspapers [the *New York Times* and the *Times* (London) in particular] and the meteorological publication *Monthly Weather Review*, when combined, proved to be a very successful tool for verifying storms that were previously known and for

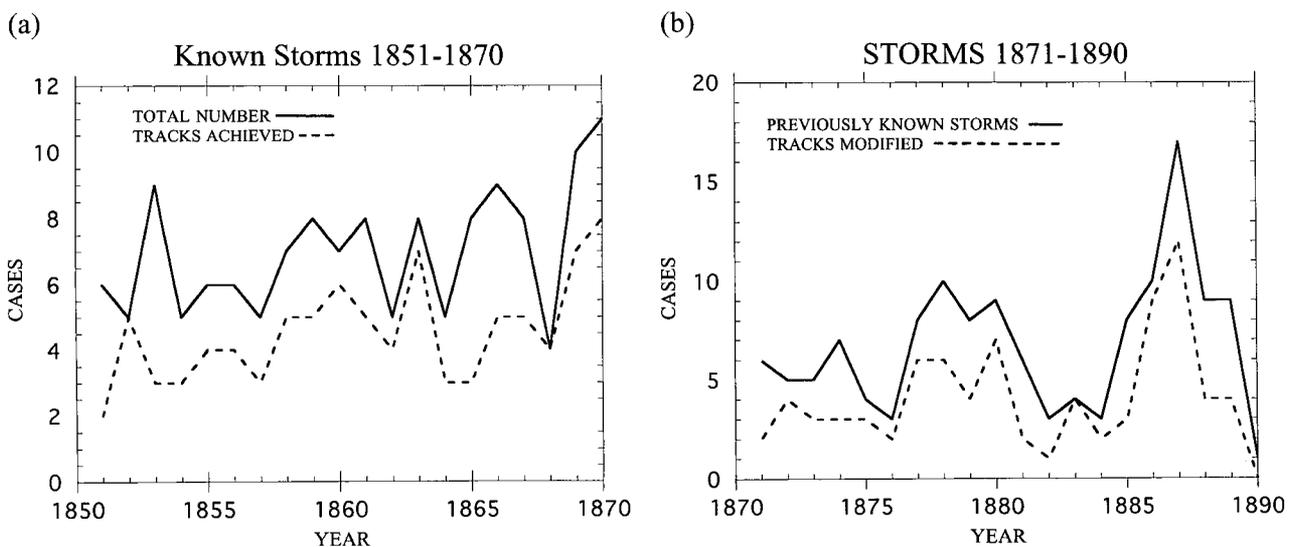


FIG. 5. Graph illustrating (a) the number of storm tracks achieved versus total number of known storms for 1851-70 and (b) the number of tracks for 1871-90, which were modified in some manner as a result of this study.

documenting new ones, resulting in a historically significant revision of Atlantic tropical cyclones over the period 1851–90. Specifically, the use of these historical sources permitted us to establish tracks for a large number of storms and to introduce corrections to previously established tracks for storms that occurred during the second half of the 40-yr period. The degree of success achieved in expanding and improving the historical archive of Atlantic hurricane counts and tracks is reflected in the increase from 193 storms catalogued previously to 298 storms now. The success is also reflected in newly established tracks (114), in the concurrence with the positioning of previous tracks (53), and in the modification of existing tracks (82) for 249 out of the 298 storms with documentation for the period 1851–90. It seems likely that an extension of this study to the last 10 yr of the nineteenth century, and perhaps also into the early twentieth century, would produce similarly useful results as those so far obtained.

Future work will continue to evaluate potential new sources of information on tropical cyclone occurrences in the North Atlantic. Another focus will be on the continuation of efforts at compiling a comprehensive list of the more deadly storms (Rappaport and Fernández-Partagás 1996) of the past few centuries as an aid to the assessment of hurricane hazards. The authors are collaborating with the Tropical Prediction Center/National Hurricane Center to use this new storm information to add and/or update the Atlantic tropical cyclone database. Eventually, the results should be incorporated into a future edition of the Neumann et al. (1993) report.

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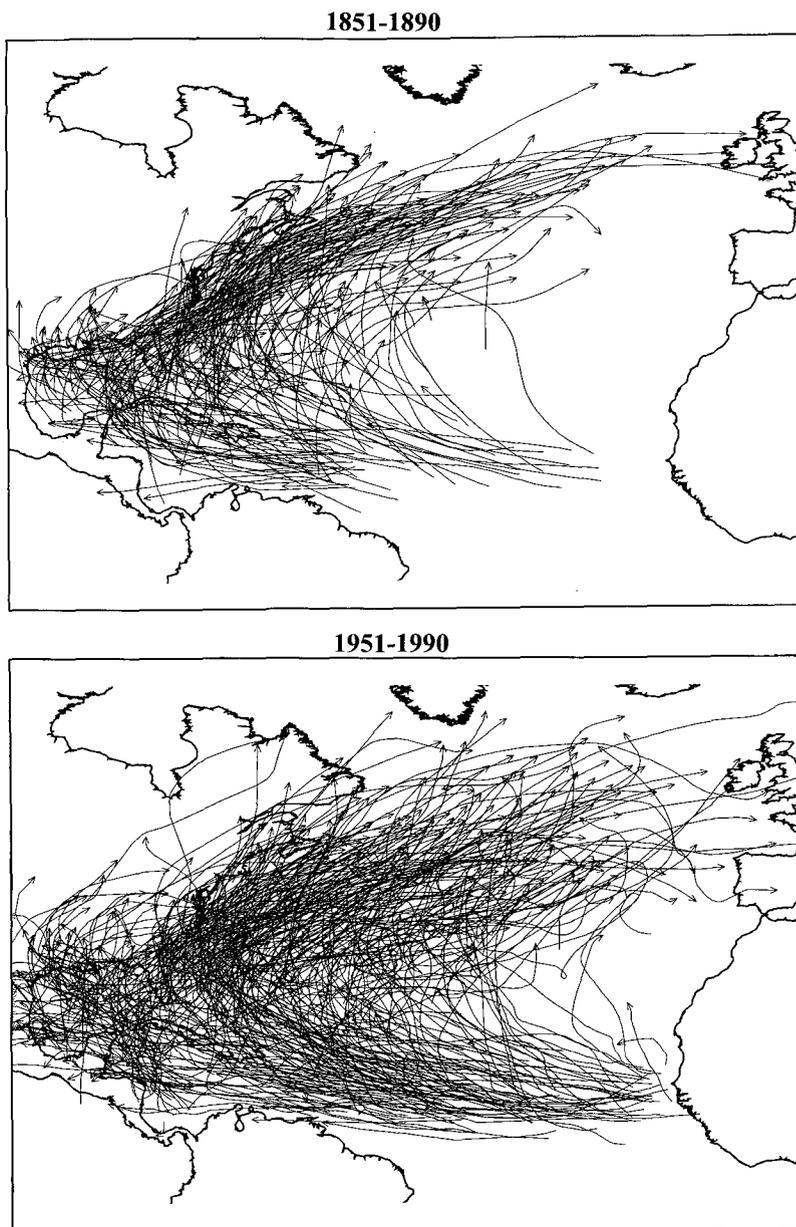


FIG. 6. Tropical storms tracks for two 40-yr periods: Top panel: 1851–1990; Bottom panel: 1951–90.

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