

**A CENTENNIAL REVIEW OF MAJOR LAND FALLING TROPICAL CYCLONES
IN SOUTHERN NEW ENGLAND
June 2000**

1. INTRODUCTION

Hurricanes and tropical storms are no strangers to Southern New England. Forty-one such storms have affected the region since 1900, 12 of which made landfall with significant impact. These 12 land-falling systems displayed similar characteristics with respect to the storm track for acceleration, high winds, storm surge and heavy precipitation. This paper will review Southern New England tropical cyclones since 1900, focusing on the similarities of these 12 land-falling systems.

2. DATA SOURCES

Track information for each tropical cyclone was obtained from the National Climatic Data Center (NCDC) Historical Climatology Series 6-2 (NCDC 1993). Storm surge information was gathered through a collection of Southern New England Hurricane Evacuation Studies produced by the U.S. Army Corps of Engineers. Rainfall analyses were obtained from prior publications (Vallee 1993, Vallee and Czephy 1996).

3. CLIMATOLOGY OF THE 12 MAJOR LAND-FALLING TROPICAL CYCLONES.

Table 1 shows the major tropical cyclones which have struck Southern New England since 1900.

TABLE 1

Twelve significant tropical cyclones impacting Southern New England, 1900-1999. Storm intensity at landfall is given by the Saffir/Simpson scale or TS for tropical storm. Forward motion is at the time of landfall (km/hr).

Name	Date	Intensity	Forward Motion
Unnamed	7/21/1916	CAT 1	29
Unnamed	9/21/1938	CAT 3	82
Unnamed	9/14-15/1944	CAT 3	47
Carol	8/31/1954	CAT 3	56
Edna	9/11/1954	CAT 3	74
Diane	8/18-20/1955	TS	24
Donna	9/12/1960	CAT 2	39
Belle	8/9-10/1976	CAT 1	32
Gloria	9/27/1985	CAT 2	72
Bob	8/19/1991	CAT 2	51
Bertha	7/12-13/1996	TS	48
Floyd	9/18/1999	TS	56

Tropical cyclones that impacted the region have come from either tropical waves that matured into tropical storms in the western Atlantic (so called "Cape Verde" storms), or from systems that developed in the vicinity of the Bahama Islands. Of the 12 major land-falling systems, nine originated from the "Cape Verde" tropical waves, including the Great New England Hurricane of 1938 (CAT 3), while the remainder originated in the Bahamas, including Hurricane Carol in 1954

(CAT 3).

3.1 Seasonal Distribution

Southern New England has experienced at least one major land-falling system in each decade of the 1900s, except the 1920s. The 18 year period from 1938 to 1955 was quite active with five major systems, including four Category 3 hurricanes. The 15 year period from 1985 to 1999 was also active with four major systems, including two Category 2 hurricanes. Perhaps the most interesting statistic with regard to frequency is that since 1954, there have been no land-falling Category 3 Hurricanes.

3.2 Monthly Distribution

August and September were the most active months for tropical cyclone activity in Southern New England, with 10 occurrences. The remaining two occurred in July.

4. COMMON CHARACTERISTICS OF THE 12 LAND-FALLING TROPICAL CYCLONES

Each of these 12 systems, with varying degrees of impact, brought high winds, coastal flooding, and heavy precipitation to the region. Each system experienced some degree of forward acceleration. The core of strongest winds and the largest storm surges were always focused east of the storm track. The heaviest precipitation was always focused along and west of the storm track.

4.1 Forward Motion

Each system displayed significant northward acceleration. The average forward speed at time of landfall was 51 km/hr, while 82 km/hr was observed with the Great New England Hurricane of 1938.

Synoptically, one of two upper level patterns were associated with the rapid acceleration: a deepening long wave trough or the rapid formation of a cut-off low in the vicinity of the Great Lakes and Ohio Valley. The rapid acceleration enhanced high winds, storm surge and heavy precipitation.

4.2 Wind

The rapid acceleration of these systems produced a rather short duration of both tropical storm and hurricane force winds, when compared to slower moving tropical cyclones elsewhere in the western Atlantic. The average duration of tropical storm force winds ranged from 12 to 15 hours. Hurricane force winds were generally produced for three to six hours centered around the time of landfall.

Systems accelerating up the coast were often embedded in deep layer southerly flow. In the Northern Hemisphere, the components of surface wind and the mean flow act in the same direction, producing enhancement (Elseberry et al. 1987). Also, as this acceleration occurs, the eye diameter expands, causing an eastward displacement of the radius of maximum wind (RMW). This pattern was observed in Hurricane Bob, with a RMW of approximately 40 km (National Weather Service 1992), and in the Great New England Hurricane of 1938 with a RMW of over 64 km.

4.3 Storm Surge

The rapid acceleration impacts the magnitude of the storm surge. Wind stress and pressure gradient are the key components in surge production, with wind stress accounting for approximately twice the surge produced solely by pressure gradient (Anthes 1982). The angle at

which the systems made landfall in Southern New England was generally 60 to 90 degrees, or close to perpendicular to the coastline, aiding in surge production on north-south oriented bays and inlets.

While the stronger tropical storms produced surges of 0.5 to 1 m, the Category 2 and Category 3 storms generated storm surges in excess of 4 m. For the two most powerful storms, the Great New England Hurricane of 1938 and Hurricane Carol, the RMW was focused on eastern Connecticut and Narragansett Bay. Surge modeling indicates for a storm similar to Hurricane Carol, surges in excess 8 m will occur on portions of Buzzards Bay (U.S. Army Corps of Engineers 1997).

4.4 Rainfall

Nearly half of all tropical cyclones that impacted Southern New England since 1900 produced significant river and small stream flooding. Heavy rainfall typically developed well in advance of the storm center, in response to the dramatic increase in moisture advection and a rapidly destabilizing atmosphere produced by a deepening upper level trough or cut-off low. In addition, as shown by Vallee and Czephyra (1996), strong east or southeast inflow produced an enhancement of rainfall in upslope regions of the major river basins in the region. The duration and strength of this inflow was critical to the magnitude of the enhancement. Tropical cyclones tended to maximize both components, thus explaining why, in spite of such a rapid forward motion, tropical cyclones impacting Southern New England also produced widespread torrential rainfall.

Typically, the first bands of heavy rainfall arrived 12 to 15 hours in advance of the storm center. The average rainfall of 150-200 mm was west of the track of the storm, with the heaviest amounts in orographically favored locations. East of the storm, two inches or less was common. Hurricane Bob, a tight Bahama-born system, produced a dramatic rainfall distribution across Rhode Island with a maximum of over 170 mm in the northwest and less than 12 mm in the southeast. Tropical Storm Diane, one of the slower moving systems, produced 250-500 mm of rain in orographically favored portions of the Connecticut River Valley.

5. SUMMARY

Major land-falling tropical cyclones in Southern New England during the last 100 years have all displayed similar characteristics with regard to forward motion, distribution of wind, storm surge, and heavy precipitation. An average forward motion at landfall has been computed at 51 km/hr. The core of strong winds and resulting storm surges were focused east of the track, while rainfall was significantly enhanced along and west of the storm track. The consistency in the behavior of these land-falling systems should allow forecasters and emergency managers to better anticipate and prepare for the evolution of the storm's impact across the region.

6. REFERENCES

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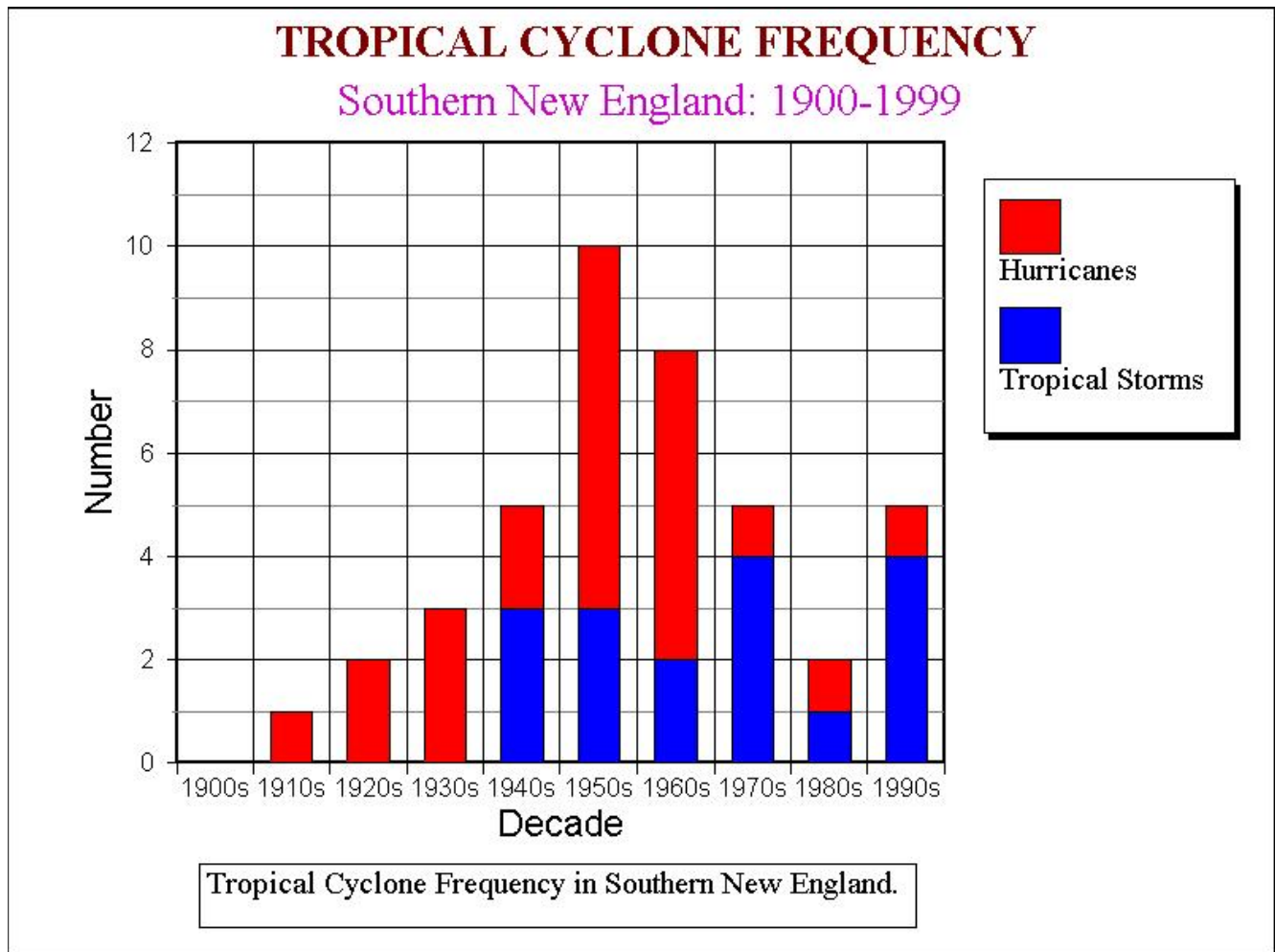
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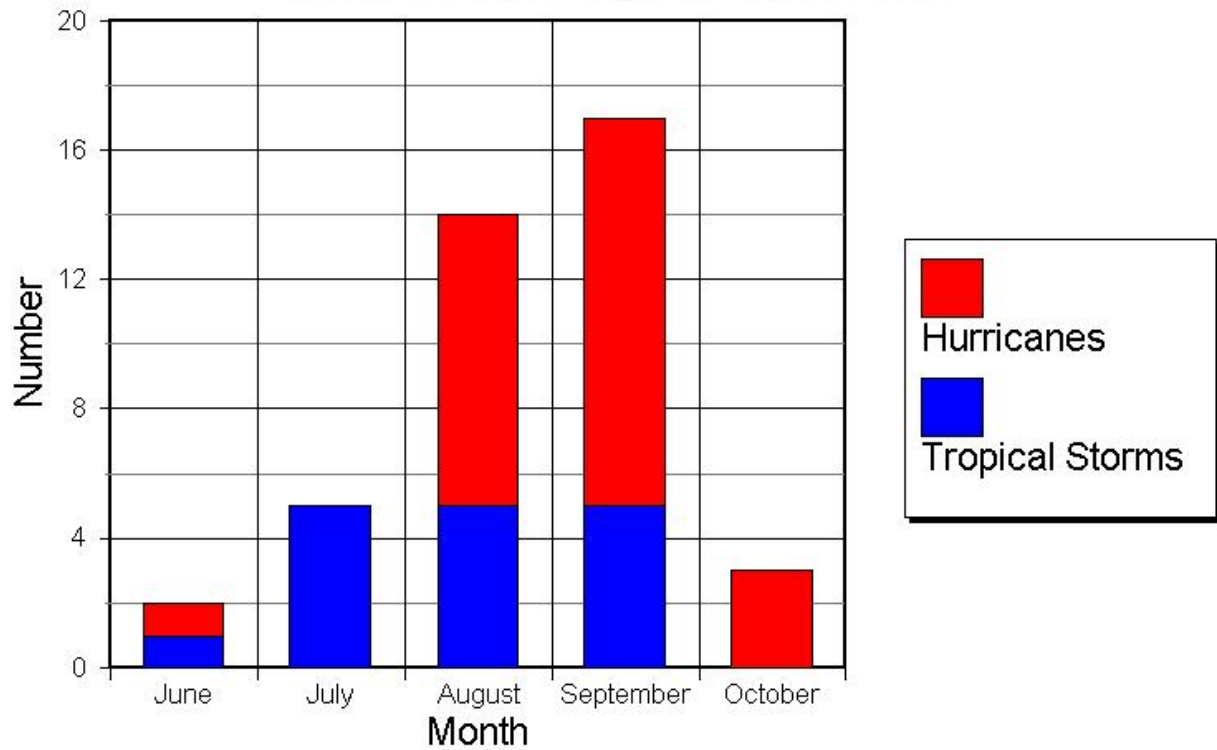
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MONTHLY TROPICAL CYCLONE DISTRIBUTION

Southern New England: 1900 - 1999



Monthly Tropical Cyclone Distribution for Southern New England.