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WEATHER BUREAU  
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TECHNICAL MEMORANDUM NO. 4

Tornadoes Associated with Cyclones of Tropical Origin--  
Practical Features

by

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## FOREWORD

This summary of inferences for forecasting has been taken from a much more extensive study of tornadoes associated with tropical cyclones which the authors have submitted to the Journal of Applied Meteorology for possible publication. The authors have kindly prepared the summary at the request of the Scientific Services Division so that other forecast offices along the Gulf and South Atlantic coasts may share in the benefits of the results of this excellent study of a very difficult and important forecasting problem.

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REGION II TECHNICAL MEMORANDUM NO. 4

TORNADOES ASSOCIATED WITH CYCLONES OF TROPICAL ORIGIN--PRACTICAL FEATURES

SYNOPSIS OF FORECASTING ASPECTS

Special Tornado Situations. The conclusions offered pertain only to tornadoes associated with tropical cyclones.

Parent Cyclone Stages. It has been found advantageous for tornado forecasting to categorize the parent tropical cyclones into the following stages:

Formative (F)--cyclones of less than hurricane intensity during the entire period of genesis.

Hurricane (H)--cyclones of hurricane intensity, to the time of landfall.

Weakening (W)--hurricanes immediately after landfall and while deteriorating tropical storms.

Decaying (D)--deteriorating cyclones, while remaining tropical in structure, with winds generally less than 35 kt and rain or showers throughout the central portions.

Extra-tropical (X)--cyclones in the process of losing tropical characteristics as they become associated with baroclinic features such as fronts, troughs, westerly wind flow aloft, etc. This stage may follow either the weakening or decaying stages.

Inferences for Forecasting. Attention to the six selected figures and their legends will, for the most part, explain the reasoning behind the conclusions listed below. Tornadoes have been shown to be unlikely with:

1. Tropical cyclones moving into the Atlantic coast of the United States, except those moving almost northward into Florida or South Carolina while in the hurricane stage. (See Fig. 1)
2. Tropical cyclones, any stage, that have a heading more westward than about 340 deg azimuth (See Fig. 2), (great, or intensifying hurricanes, such as Carla, 1961, should probably be considered as exceptions).
3. Tropical cyclones of less than hurricane intensity, that appear to have reached maximum or static intensity before moving inland. (Tropical storms that never reached hurricane intensity resulted in no tornadoes during the past decade.)

The existence of a high probability of tornado occurrence has been shown to exist with:

1. Tropical cyclones, having reached hurricane intensity, or showing indications of rapid intensification, that approach the northern coast of the Gulf of Mexico or the west coast of Florida with a heading generally northward to northeastward. (During the past decade, tornado occurrences have been associated either with hurricanes or intensifying tropical depressions.)
2. Tropical cyclones of hurricane intensity at landfall, after reaching any deteriorating stage, or better still, that tend to become extra-tropical while moving northeastward across southeastern United States, or that approach the Carolinas in the decaying stage (80 per cent of the tornado occurrences in the Carolinas and Virginia during the past decade were associated with deteriorating stages of cyclones that had a Florida landfall as a hurricane).

The most likely location of tornado occurrences has been shown to be:

1. In the tropical cyclone sector from 10 deg. clockwise to 120 deg. azimuth (without regard to cyclone heading), for all stages except the extra-tropical (See Figs. 3, 4, and 5).
2. In the sector from 70 deg. clockwise to 200 deg. azimuth when the parent cyclone is in the extra-tropical stage (See Fig. 4).
3. Within a radial distance of about 60 to 300 nautical miles from the cyclone center, but may occur at distances up to 360 nautical miles with large hurricanes, or at distances up to 500 nautical miles with the extra-tropical stage with associated fronts, etc. (See Figs. 3 and 4).
4. Within certain environmental sea level pressures (See Fig. 5):
  - a. With the formative and decaying stages, 90 per cent probability within 1008-1012 mb.
  - b. Hurricane stage, 75 per cent within 1002-1008 mb.
  - c. Weakening stage, 65 per cent within 996-1004 mb.
  - d. Extra-tropical stage, 80 per cent within 1002-1010 mb. (The environmental pressures in the hurricane stage are, incidentally, typical of the so-called "bar" pressures, which roughly demarcate the outer limits of gale force winds.)
5. Along vigorous radar rainbands (spiral bands), especially an outer rainband, with cellular appearance, vertical extent greater than adjacent echoes, and longevity of more than a couple of hours. (The probability of tornado activity is higher if the radar echo pattern, in general, appears disorganized, possibly due to dry air intrusion into the circulation--thus implying the existence of convective instability.)

6. Within about one degree latitude of the coast when the parent cyclone is in the formative or hurricane stages, and within about three degrees latitude of the coast with the other cyclone stages (See Fig. 6).

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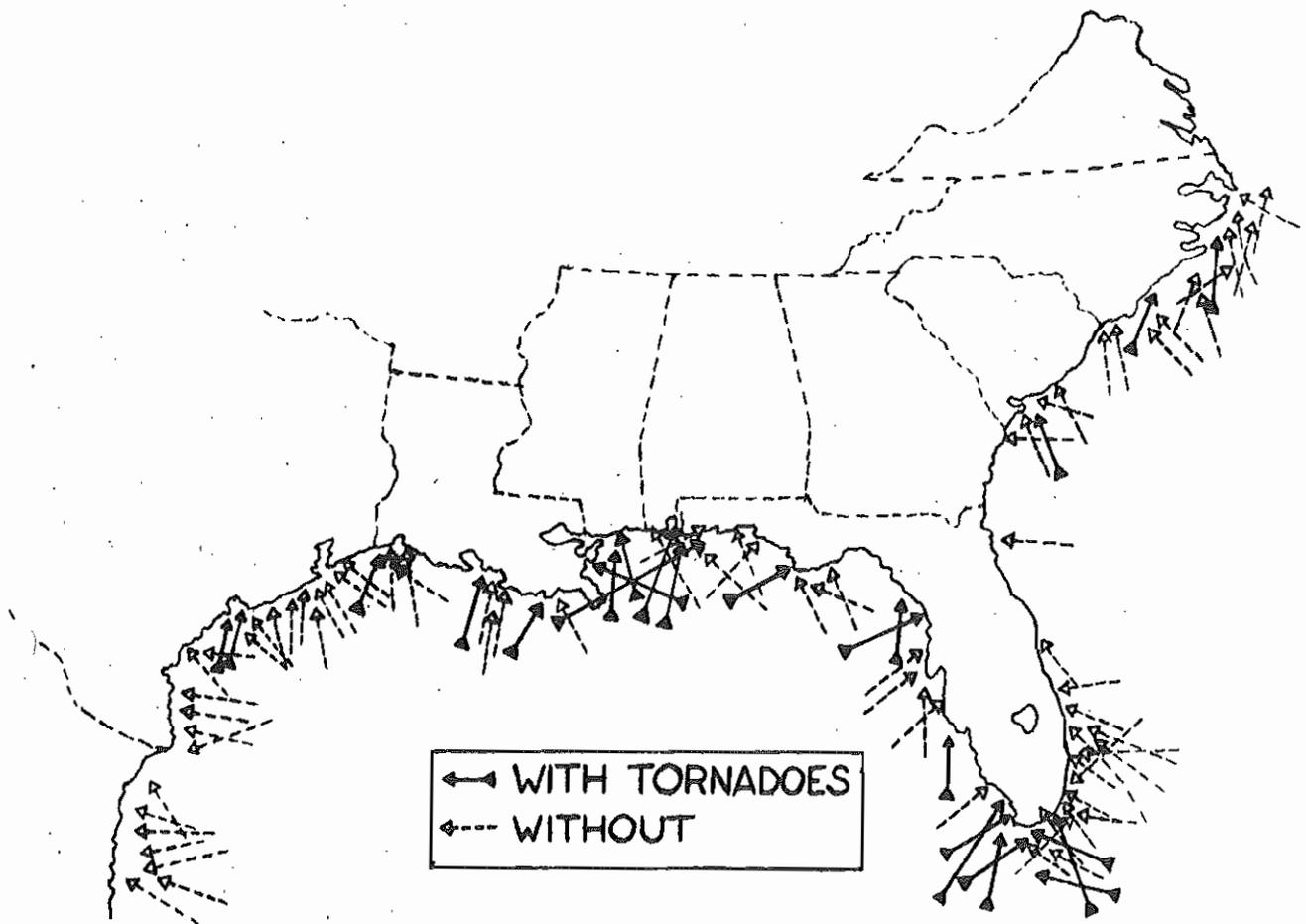


Fig. 1. Heading of tropical cyclones with hurricane intensity, at the time of landfall, 1916-1964, Tampico, Mexico to Hatteras, North Carolina. Solid arrows indicate tornado occurrence with the hurricane stage, dashed arrows indicate landfalls barren of tornadoes. (See Section 4 of text for explanation of hurricane stage).

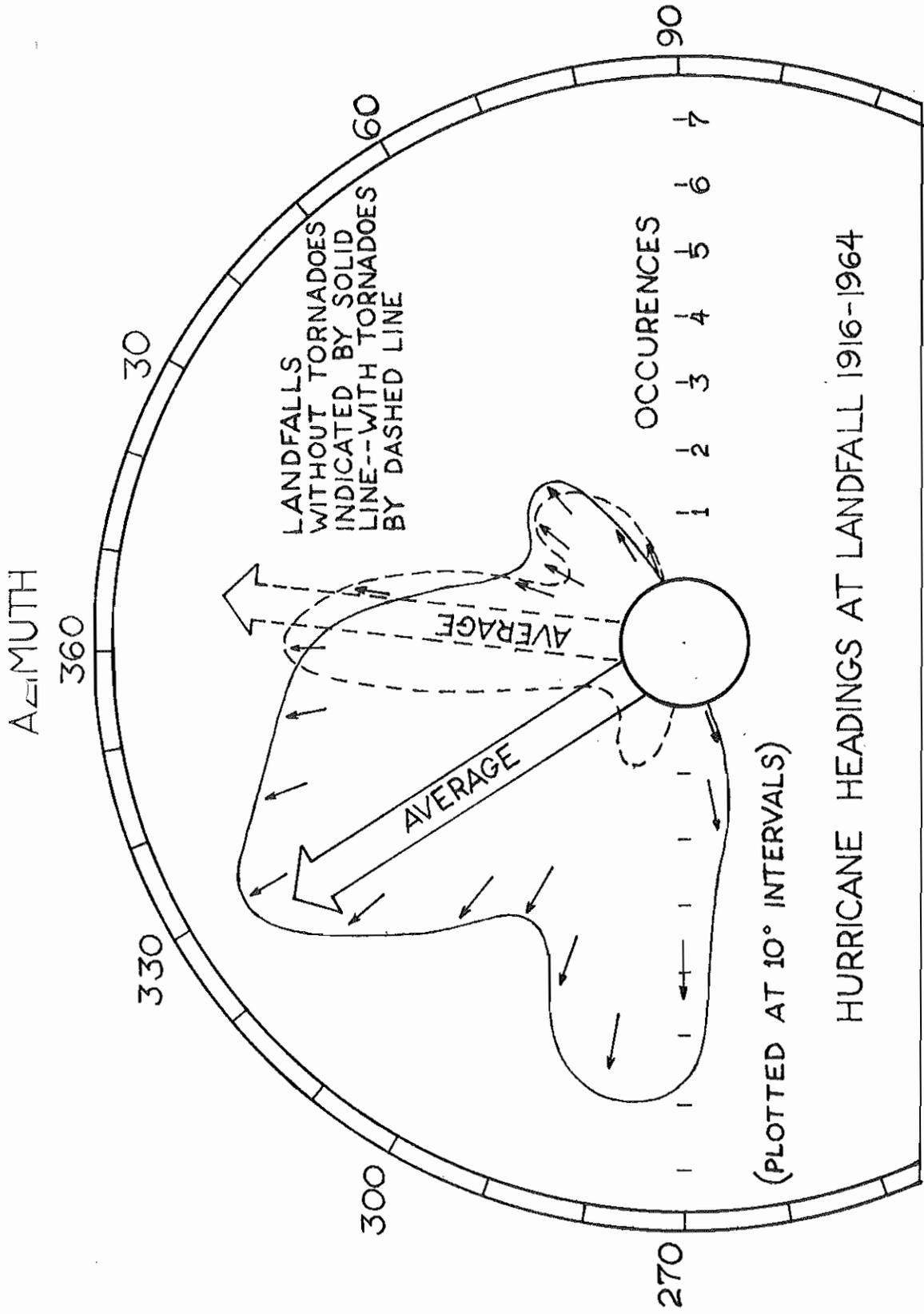


Fig. 2. Polar graph (plotted at 10 deg intervals and smoothed) showing headings and averages of hurricanes which had associated tornadoes with the hurricane stage (dashed lines) and those without associated tornadoes (solid lines), 1916-1964, Tampico to Hatteras.

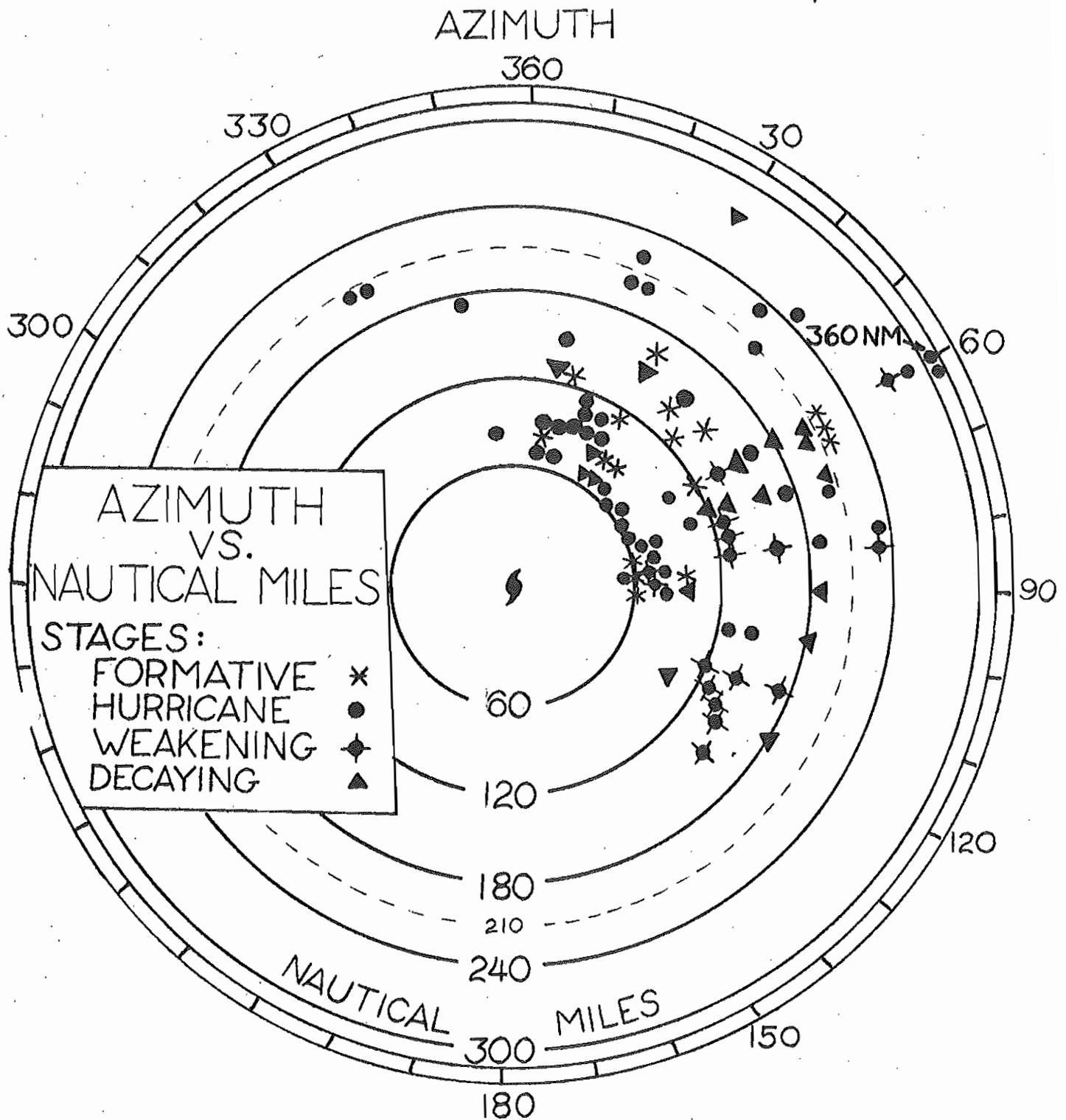


Fig. 3. Polar plot, azimuth angle versus nautical mile range distances, of tornado occurrences, 1955-1964, according to four selected tropical cyclone stages. (See Section 4 of text for explanation of stages).

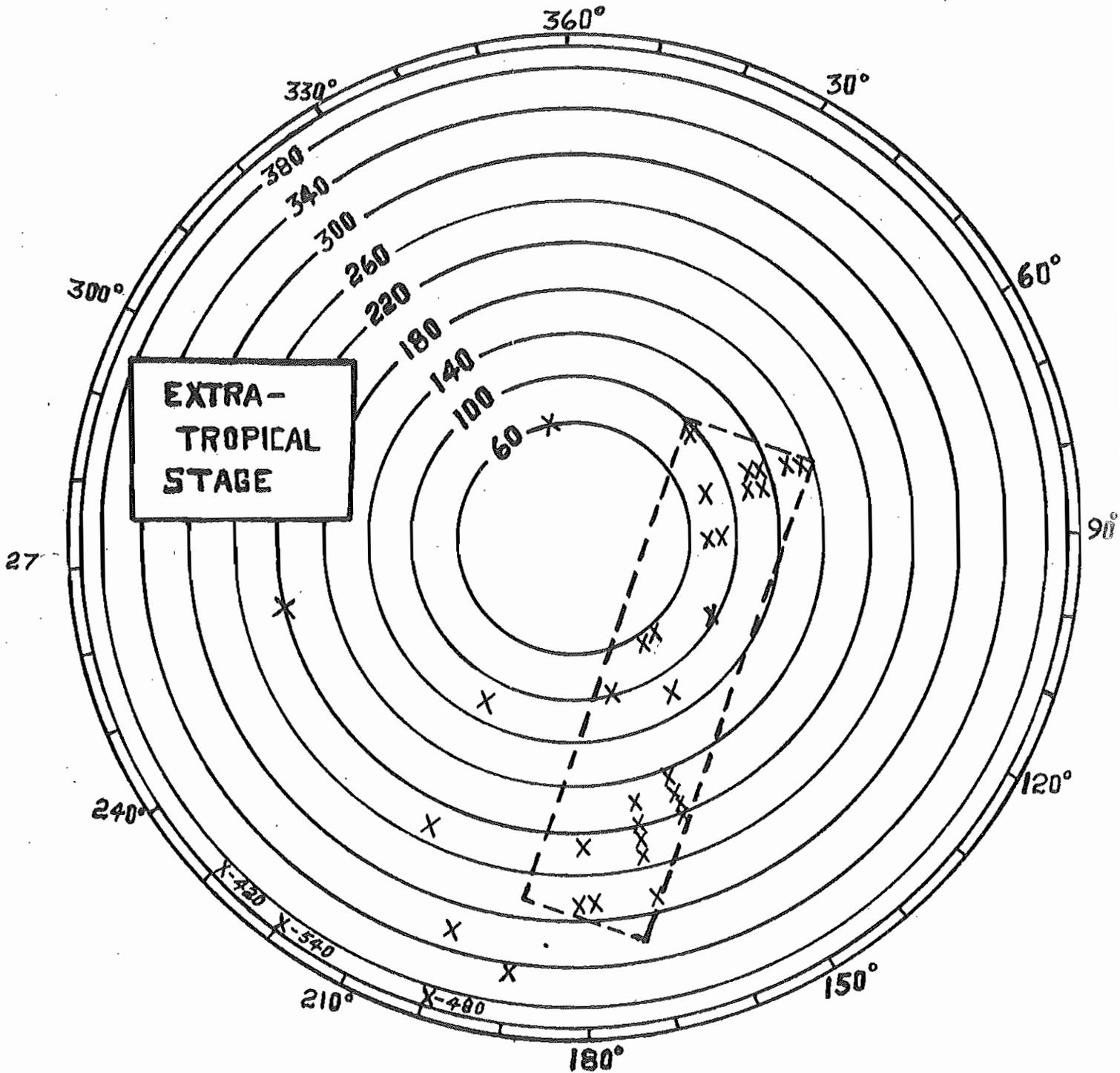


Fig. 4. Polar plot, azimuth angle versus nautical mile range distance, of tornado occurrences, 1955-1964, with the extra-tropical stage of tropical cyclones, showing "box" of maximum incidence (dashed line).

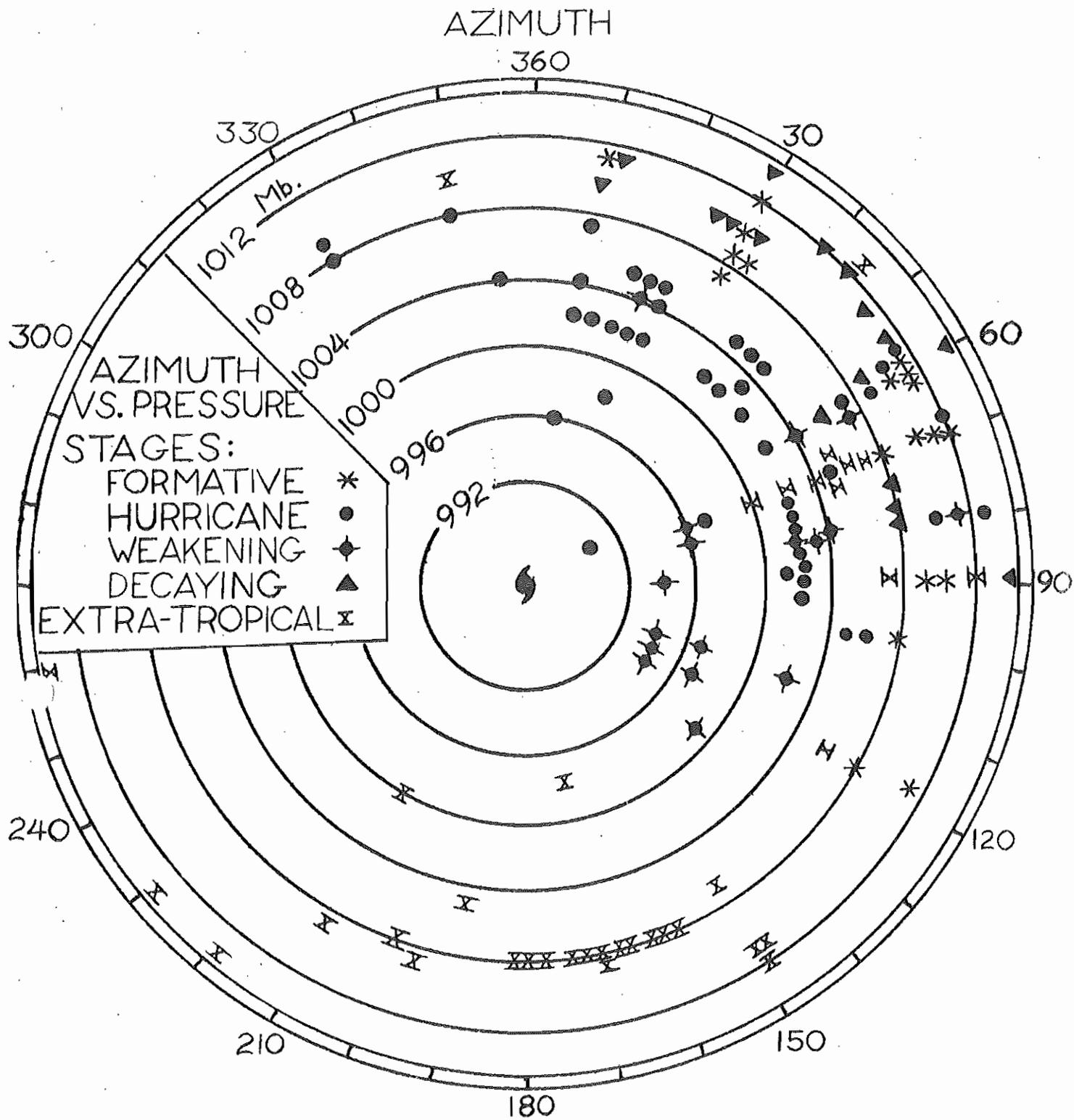


Fig. 5. Polar plot, azimuth angle versus sea level pressure field of tornado occurrences, 1955-1964, according to five selected tropical cyclone stages. (See Section 4 of text for explanation of stages).

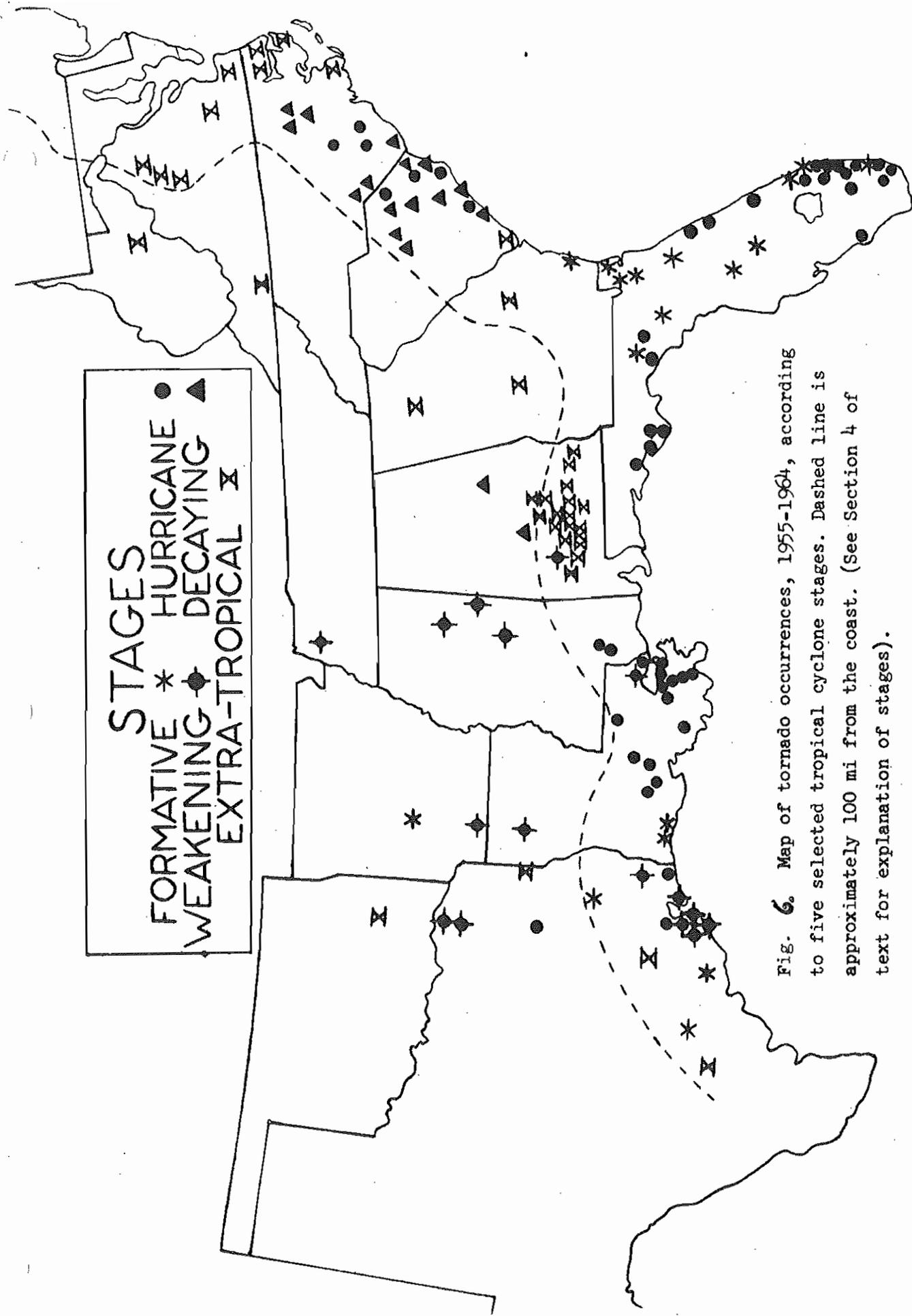


Fig. 6. Map of tornado occurrences, 1955-1964, according to five selected tropical cyclone stages. Dashed line is approximately 100 mi from the coast. (See Section 4 of text for explanation of stages).