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Radar Measurements of the Initial Growth of Thunderstorm Precipitation Cells *

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Abstract

Sequence photographs of the PPI and RHI radar 'scope presentations of a thunderstorm in the initial stages of precipitation are utilized for measurements of the vertical and horizontal growth and propagation of the storm. Rapid vertical growth, after the first precipitation cell was detected, and uniform horizontal growth are observed.

Introduction

The rate of growth and propagation of convective precipitation cells, of direct interest to the physical and synoptic meteorologist, may be measured from the radar presentations of such cells. The following measurements of the growth of a thunderstorm were taken from observations made at Cambridge, Massachusetts, on June 28, 1948.

Two radar sets and presentations were utilized. Horizontal projections were obtained from an SCR–615 (10 cm) radar with PPI (Plan Position Indicator) presentation; and an AN/TPS–10 (3 cm) radar with RHI (Range Height Indicator) presentation was used for vertical projections of the precipitation cells. In-flight measurements of the vertical gusts and drafts and the liquid water content of the air were also made.

Development of the Storm

This thunderstorm first appeared as a small and completely isolated cell and then developed rapidly both in horizontal and vertical extent. The rapidity of the horizontal growth of the storm may be judged from Figure 1. A plot of horizontal area covered by the precipitation versus the time is shown in Figure 2. It is interesting to note the uniformity of this horizontal growth. No cellular structure is defined by the PPI presentation but this must be attributed, at least in part, to the rather poor resolution of the SCR–615 radar whose beam width is 4°. No corrections were applied for beam width or pulse length since the former tends only to elongate the storm along an axis normal to the beam and the latter is completely negligible, being only of the order of 500 feet [1].

The cellular characteristics of the thunderstorm are well defined by the RHI presentations, as shown in Figure 3. The portion of the storm scanned by the AN/TPS–10 radar may be determined by reference to the appropriate time and azimuth in Figure 1. Two small precipitation cells were first detected but these quickly merged and then grew rapidly in both horizontal and vertical extent. The development of a second large precipitation cell is shown in the last three RHI presentations.

The following table summarizes the horizontal and vertical development of the storm as a whole:

Time (EST)	Heights		Area covered by storm (Sq. miles)
	Base (Ft)	Top (Ft)	
1431	11,000	18,000	—
1441	4,000	29,000	18
1451	Ground	28,000	57
1501	Ground	29,000	96
1511	Ground	>30,000	140
1521	Ground	>30,000	197

Rates of Growth

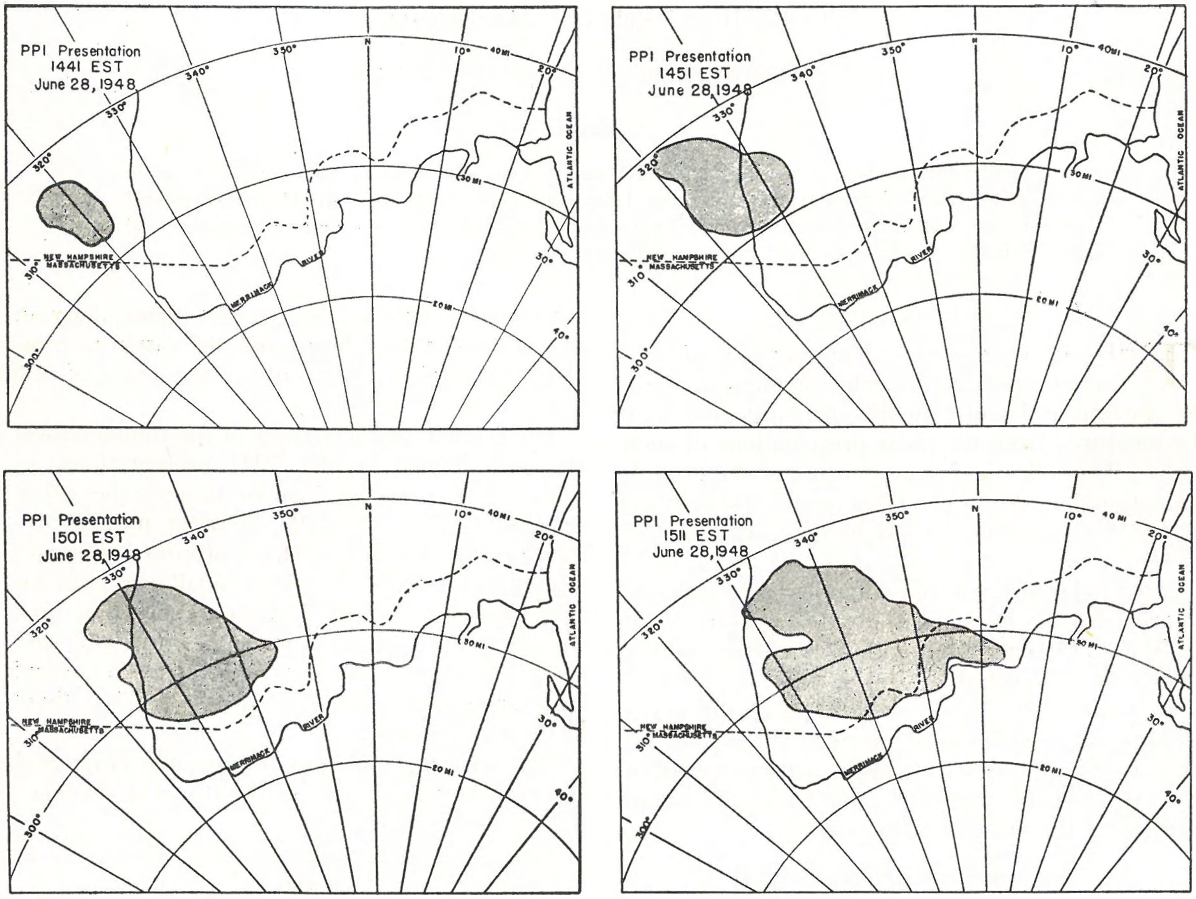
As previously pointed out the rate of horizontal growth of the storm is remarkably uniform. This horizontal growth proceeded at the rate of approximately four square miles per minute with a slight acceleration during the last twenty minutes.

* This paper is based on observations made by the Weather Radar Research project under Signal Corps contract No. W–36–039–SC–32038.

[1] Now with Hanford Eng. Works, Richland, Wash.

This observation may not be extended to the increase in total volume of precipitation, however, due to the storm's cellular structure; and it must be remembered that only the radar echo was measured, not the visual cloud.

The rate of vertical growth of the precipitation cells may be computed for the first ten minutes only. The downward rate of growth, taking 11,000 feet as the initial base, is 700 ft/min, which is approximately one-half the fall velocity of a 3-mm drop [2]. The upward growth is approximately 1,000 ft/min during the first ten minutes.



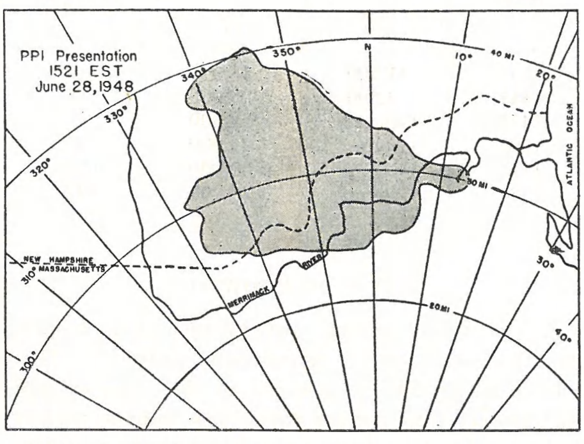


FIG. 1. PPI presentation of the precipitation cells for ten-minute intervals from 1441 EST to 1521 EST.

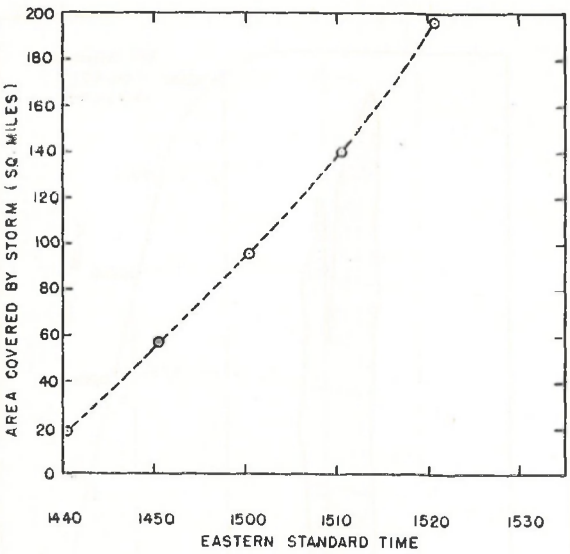


Fig. 2. Horizontal growth of the precipitation cells.

In-Flight Measurements

An airplane traverse of the storm was made along azimuth 338°, outbound from MIT, at 5,000 feet and 1517 EST. The vertical gusts, drafts, and liquid-water content encountered are shown in Figure 4. Vertical gusts were computed from pitch-angle measurements and also from vertical accelerations. In the latter computations all accelerations due to pilot control were removed and the true effective gusts were computed by NACA methods for sharp-edged gusts [3]. The vertical drafts were computed from observed changes in altitude. Liquid-water content was measured by use of a capillary collector [4]. The observations of liquid water were averaged over fifteen second intervals; hence a maximum in excess of seven grams per cubic meter was probably present.

A strong downdraft was encountered very soon after entering the storm and high values of vertical gusts were coincident with this downdraft. However the maximum liquid water was encountered immediately after the downdraft and in an area of general updrafts. Adjacent effective gusts of − 17 ft/sec and + 22 ft/sec give an excellent measure of the extreme turbulence present in this thunderstorm.

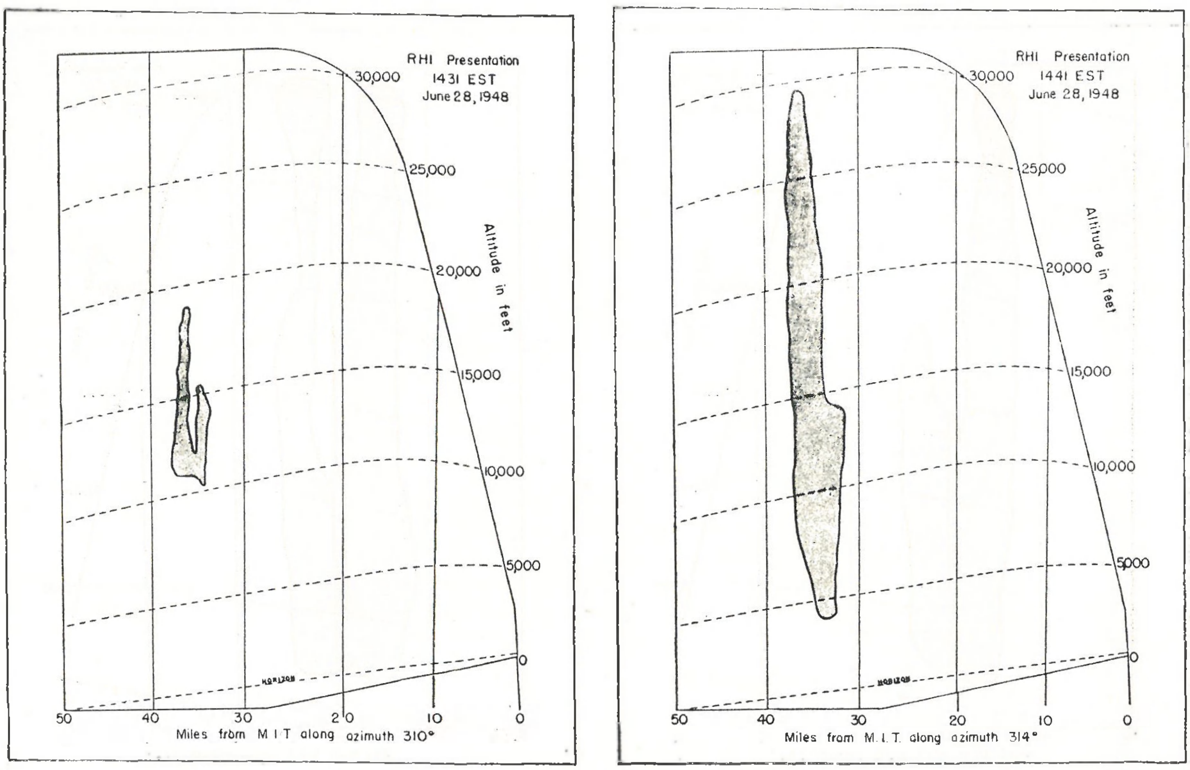


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Fig. 3 (continued, page 98)

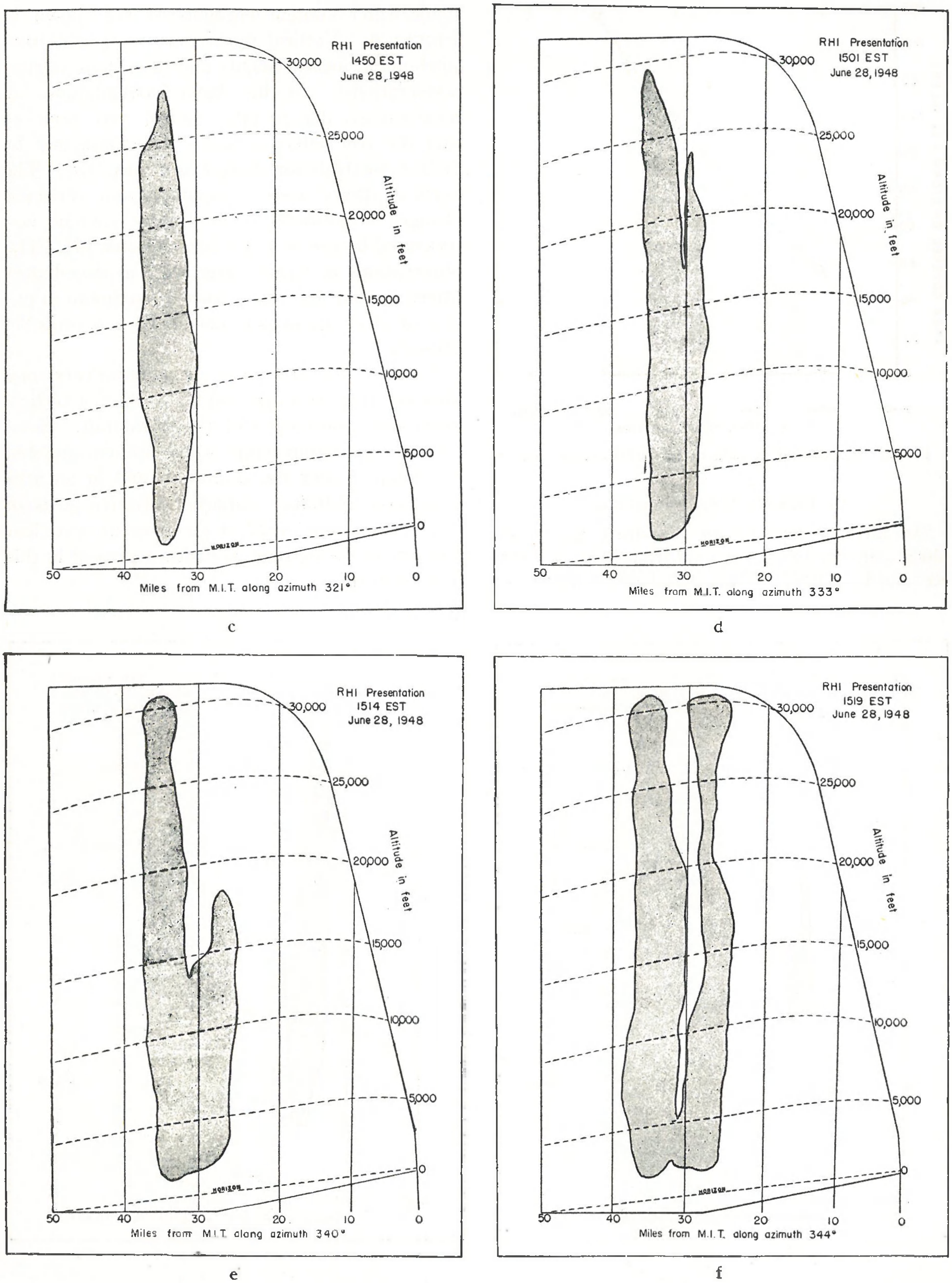
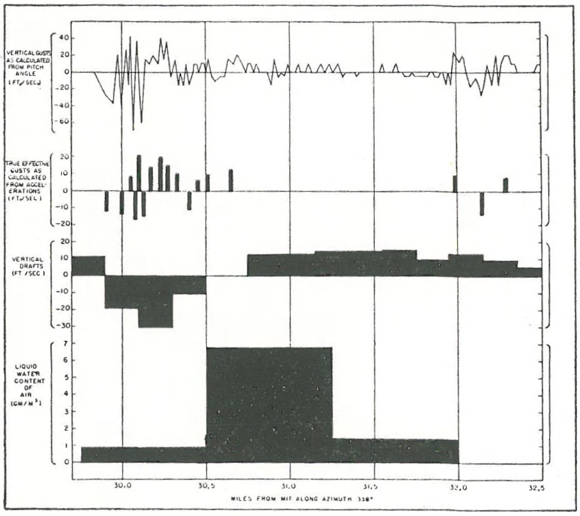


FIG. 3. RHI presentation of the precipitation cells at approximate ten-minute intervals beginning with first detection of the storm at 1431 EST.



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[1] M.I.T., Department of Meteorology, *First Technical Report Under Signal Corps Project* (Contract No. W-36-039-SC-32038), December 31, 1946, pp. 17-22.

[2] *Op. cit.*, Fig. X.

[3] *Airplane Airworthiness*, part 04 of "Civil Aeronautics Manual," 1944. (Based on NACA reports which are not yet generally available.)

[4] Vonnegut, B., A Capillary Collector for Measuring the Deposition of Water Drops on a Surface Moving Through Clouds, *The Review of Scientific Instruments*, Vol. 20, No. 2, 110–114, February, 1949.

FIG. 4. In flight measurements at 1517 EST. Top curve: vertical gusts in ft/sec; second row: true effective gusts in ft/sec; third row: vertical drafts in ft/sec; bottom row: liquid water content in gm/m.[3] The horizontal scale is miles from MIT along azimuth 338° (29.75–32.5 miles left to right).