TORNADO OR "MICROBURST"[1] ?

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On Sunday afternoon, May 22, 1983, a strong localized wind storm struck several locations east of Asheville, North Carolina. Following is a brief summary of the meteorological conditions that existed prior to and during the event, as well as a description of the resulting damage.

Before proceeding with the meteorological aspects of the storm, it would be helpful to briefly discuss the major geographic features of the area involved. The city of Asheville is located in the middle of the French Broad River Valley, which is about 10 miles wide and oriented SSE-NNW. About 20 miles NNW of the city the valley turns to the WNW and cuts through the relatively lower Bald Mountains, where it then opens into the broad SW-NE oriented Great Valley of east Tennessee.

In contrast to the SSE-NNW orientation of the French Broad River Valley, the more narrow Swannanoa River Valley is oriented WSW-ENE and empties into the French Broad River in south Asheville. The Swannanoa Valley is flanked on the north by the Black Mountains (maximum elevation 6684') and on the south by the Swannanoa Mountain Range (maximum elevation 4400'). It was in the western end of the Swannanoa Valley and on the north flank of the Swannanoa Mountain Range that the wind damage occurred (see Figure 1).

Sunday, May 22, 1983, started out as an overcast, windy day in Western North Carolina. There had been some showers and even a couple of thundershowers during the early morning hours; however, none of the thundershowers approached the intensity of the storms that occurred later in the day.

Synoptically, the southern Appalachians were in a moist unstable air mass that preceded a NE-SW oriented cold front that was approaching the area from the WNW. Thunderstorms had developed ahead of the front as it moved through east Tennessee, east Kentucky, and the upper Ohio Valley. Some of the storms had reached severe levels and had produced hail and several tornadoes.

Wind speeds ahead of the front were quite strong from the south through southwest from the surface to the 200mb level. The surface winds in the Asheville area were stronger than usual for a late spring cold frontal episode with the Asheville WSO (Elevation 2165') reporting gusts to 26 knots three hours prior to the storm, and the Flat Top Mountain cooperative station (Elevation 4370') reporting gusts to 40 knots during the same period. Winds aloft increased with height over the area. The 850mb winds were 200° at 35 knots and increased to 70 knots from 230° at 200mbs. The axis of the 500mb trough at 0700 EST on May 22nd was oriented NW-SE from northwest Minnesota to north central Georgia.

[1]Term described by Fujita as a "Microscale downburst with its path length less than 3.16 miles." Fujita, T. T., (1978): Manual of downburst identification for project NIMROD.

Both the 0700 and 1900 EST soundings for Athens, Georgia showed the atmosphere to be conditionally unstable with a Lifted Index of -1 and -3, respectively. However, during the intervening 12-hour period a major change had occurred in the moisture profiles, with the lower levels (900-600mbs) becoming more moist and the upper levels (above 600 mbs) drying out dramatically. Such a moisture profile is often synonymous with the outbreak of severe thunderstorms.

Not unlike other thunderstorm lines that move into the southern Appalachians from the west, this one also became less organized. The only exception was in the area where the French Broad Valley provided a significant break in the Appalachian Mountain barrier, and as a result allowed a portion of the thunderstorm line to move into the north end of the French Broad Valley.

The sky was dark to the NW of Asheville during the early afernoon with thunder beginning distant northwest at 1452 EST[2]. With the strong southwest winds aloft, however, the individual thunderstorm cells moved northeast along the remains of the line. Thunder ended distant north-northwest at 1525 EST, with the line having shown little or no movement to the southeast. At 1545 EST thunder began again to the north-northwest of Asheville, only this time it was closer and more frequent as a new series of cells developed to the southeast of the old line and the new line began to move east-southeast across Asheville. The individual cells were still moving rapidly northeast, but the line continued moving to the southeast. As the line crossed the low ridges east-southeast of the city at 1600 EST the cloud bases were ragged but mostly rain-free. At 1602 EST frequent intense lightning began in the rain-free area to the southeast through east of the existing line of cells, and at 1606 EST, in a matter of seconds, a narrow (1-2 mile wide) obscuring rain shaft dropped from the cloud base over the area that experienced the wind damage. In twenty-five years of observing thunderstorms in the East Tennessee and Western North Carolina area the author has never seen a rain shaft drop more rapidly from a cloud base than in this case. Even though the recording rain gauges in downtown Asheville and on Flat Top Mountain (9 miles to the ESE) were not in the center of the storm, both sites still recorded peak rainfall intensities of about 6 inches per hour.

The 1600 EST GOES-1 satellite photo showed at least one small overshooting top breaking through the cirrus tops from older cells (see Figure 2). Unfortunately there were no radar tops reported on this cell until 1630 EST when the Bristol, Tennessee, radar reported a height of 37,000 feet. The Athens, Georgia, and Greensboro, North Carolina, 0700 EST soundings showed the height of the tropopause to be between 43,700 and 44,000 feet. Radar photos from Bristol and Athens did show a characteristic "Bow" shaped echo that is commonly observed with intense thunderstorm episodes (see Figure 3). Despite the fact that the Bristol radar was located 50 nautical miles closer to the cell than the Athens radar, it only showed a convective VIP level 3 (1.1-2.2 inches of rain per hour) while at the same time Athens showed a convective VIP level 5 (4.5-7.1 inches of rain per hour). The Athens data more closely agree with the rainfall intensities reported by the downtown Asheville and Flat Top Mountain rain gauges. The most likely explanation for the difference in the reported VIP levels is that the Bristol radar beam was set on a 0^{o} elevation angle and was being attenuated by higher terrain between the radar site and the thunderstorm cell. It might be noted that similar differences in the VIP levels have been observed while studying several previous thunderstorm events that occurred in the same area.

As the storm approached the author's vantage point on Flat Top Mountain, the strong southerly winds subsided long enough to allow the author to hear a loud roar as the gust front came across High Hickory Knob one-half mile to the west. At 1620 EST a peak gust of 60 knots from a direction of 270° was recorded at Flat Top Mountain (see Figure 4). The peak gust was preceded a minute earlier by two gusts of 54 knots and the beginning of very heavy rain. All five individuals interviewed by the author who were in the wind damage areas agreed that the peak wind gusts occurred coincident with the onset of very heavy rain.

It was only after making an aerial survey the following day that the author and a National Climatic Data Center meteorologist discovered that the most severe wind damage had occurred in a remote uninhabited valley about one mile to the east of any damage areas that had previously been reported by the public. A careful study of the photos from five separate aerial surveys and four on-ground inspections showed that there were evidently three separate major wind damage areas, with the direction of most of the damage tracks being controlled by the orientation of the terrain.

The first damage area was centered on the Georgia Pacific Plant which is located in a shallow flood plain of the Swannanoa River (see Figure 5). Dimensions of the plant are approximately 125 feet by 250 feet with the narrow side facing a direction of about 250°. The plant is of a modular type construction of heavy corrugated steel with a large access door on the WSW side and two pull-down type doors at a loading dock on the NNW side of the building. Treefall direction on either side of the building was parallel from the southwest, indicating the direction of the winds. As a result, the large access door on the WSW side of the building was blown in, allowing the wind to move some of the wood products located inside the building. With no openings on the downwind side of the building, dynamic pressures increased enough to bulge the loading dock doors to such an extent that they could not be opened. Even portions of the plant walls were forced outward from the concrete foundation. The trailer portion of two tractor-trailers parked on the downwind side of the plant were also flipped over. One of the trailers came to rest against a large unfallen tree.

Aerial photos showed that the second damage area was centered on Potato Knob, a relatively small NW-SE oriented ridge that separates Buckeye Cove and Wilson Cove (see Figure 5). Contrary to what would normally be expected, the maximum wind damage was confined to the flanks of the ridge and the valleys either side as opposed to the more exposed ridgetop itself. There was one narrow area of treefall from SSE to NNW and parallel to the elevation contours about one third of the way down the west side of Potato Knob; otherwise, the predominant direction of treefall was downhill either side of the ridge. It was also on the southwest side of Potato Knob that a mobile home was broken free from its tie downs and moved several feet. On the east side of Potato Knob there were four damage tracks that occurred in separate narrow valleys that empty into Wilson Cove. Again the direction of treefall was downhill and concentrated in the deepest part of the valleys. Residents living in Buckeye and Wilson Coves also reported a "loud roar" prior to and with the onset of, the storm. One resident said that when the rain began it was "as if someone had thrown a large bucket of water at him."

[2]Beginning and ending times of thunder are as reported by the author from Flat Top Mountain, North Carolina.

As was previously mentioned, the most intense wind damage occurred in the third damage area in an uninhabited portion of Patton Cove. The upper part of the cove is bowl shaped with steep slopes dropping off rapidly from High Hickory Knob. There were several scattered areas of tree damage about 700 feet below the top of High Hickory Knob. The maximum damage occurred, however, about 300 feet farther below and at the focal point of four narrow valleys where the winds were concentrated (see Figure 6). A ground search of the area showed that scattered trees had fallen downhill in each of the valleys leading to the focal point. Even the tender vegetation beneath the deciduous canopy was laid downhill with the winds. Flash flooding was ruled out as the cause of the plant damage since the precipitation was not of sufficient duration to produce any overland flow and no signs of erosion were found.

The dimensions of the damaged area shown in Figure 6 are about 100 feet wide by 350 feet long. Figure 6 also shows the direction of treefall to be the same from one side of the damage area to the other, the only exception being where the steepest valley of the four empties into the damage area from the lower right as viewed in Figure 6. The result was a small area of trees that were fallen at about a 50^{o} angle to the left of the predominant treefall in this damage area.

Over 95% of the trees in the damaged areas were uprooted as opposed to being broken off above ground. This was true for various tree types and locations. The author believes that the reason for the uprooting was winds striking the trees downslope from the southeast which is opposite of their rooted strength against the predominant strong northwest winds that frequent this area. Many of the trees were also growing in rocky, shallow soil. A close examination of the root structure of the uprooted trees did confirm a minimal amount of large roots on the uphill or southeast side of the trees.

It is the conclusion of the author that the wind damage was most probably the result of a microburst as opposed to a tornado. This conclusion was reached after considering the following facts:

1. No one in the area, including the author, reported having seen a funnel cloud.

2. The strongest winds occurred with the onset of heavy rain and on the right front side of the reflectivity center of the bow echo as it moved eastward. This is the position, relative to the cell, where microbursts are likely to occur, while tornadoes are more likely to occur at the trailing ends or hook portion of the cell.

3. The vast majority of trees in the damage paths were fallen in a parallel manner and in the bottom of the valleys. Similar damage was documented by Fujita in the mountains of West Virginia after the major outbreak of storms on April 3, 1974. These narrow areas of tree damage were described by Fujita as "downburst fingers" or the "spreading ends of a downburst descending over rugged terrain."

References

Fujita, T. T., (1978): Manual of downburst identification for project NIMROD.

National Climatic Data Center

Athens, Georgia, radar film for May 22, 1983.

Bristol, Tennessee, radar film for May 22, 1983.

GOES-1 satellite photographs for May 22, 1983.

Athens, Georgia, radiosonde observations for 12Z May 22, 1983 and 00Z May 23, 1983.

Weighing rain gauge charts for National Climatic Data Center and Flat Top Mountain co-op stations for May 22, 1983.

Wind gust record for Flat Top Mountain, North Carolina, for May 22, 1983.

National Meteorological Center

Surface, 850, 700, 500, 300, and 200mb charts for 12Z May 22, 1983 and 00Z May 23, 1983.

The vorticity and LFM charts were unavailable at this time.

U. S. Department of Commerce

Federal Meteorological Handbook No. 7, "Weather Radar Observations" Part A; Effective January 1, 1980.

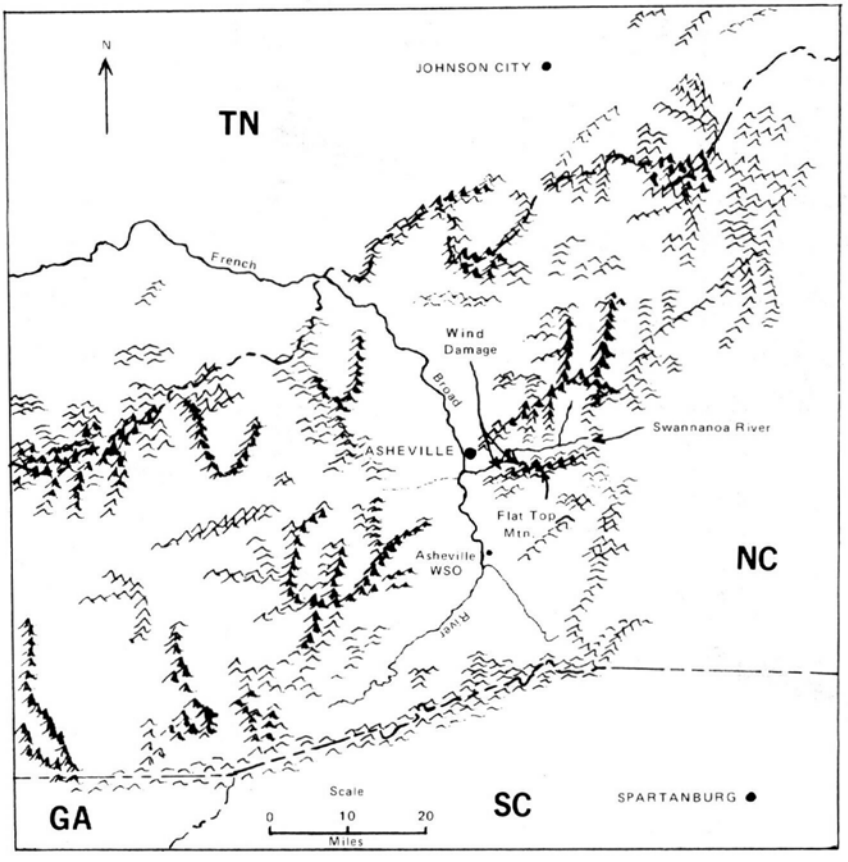

Figure 1. Locations and topographical features of Western North Carolina.

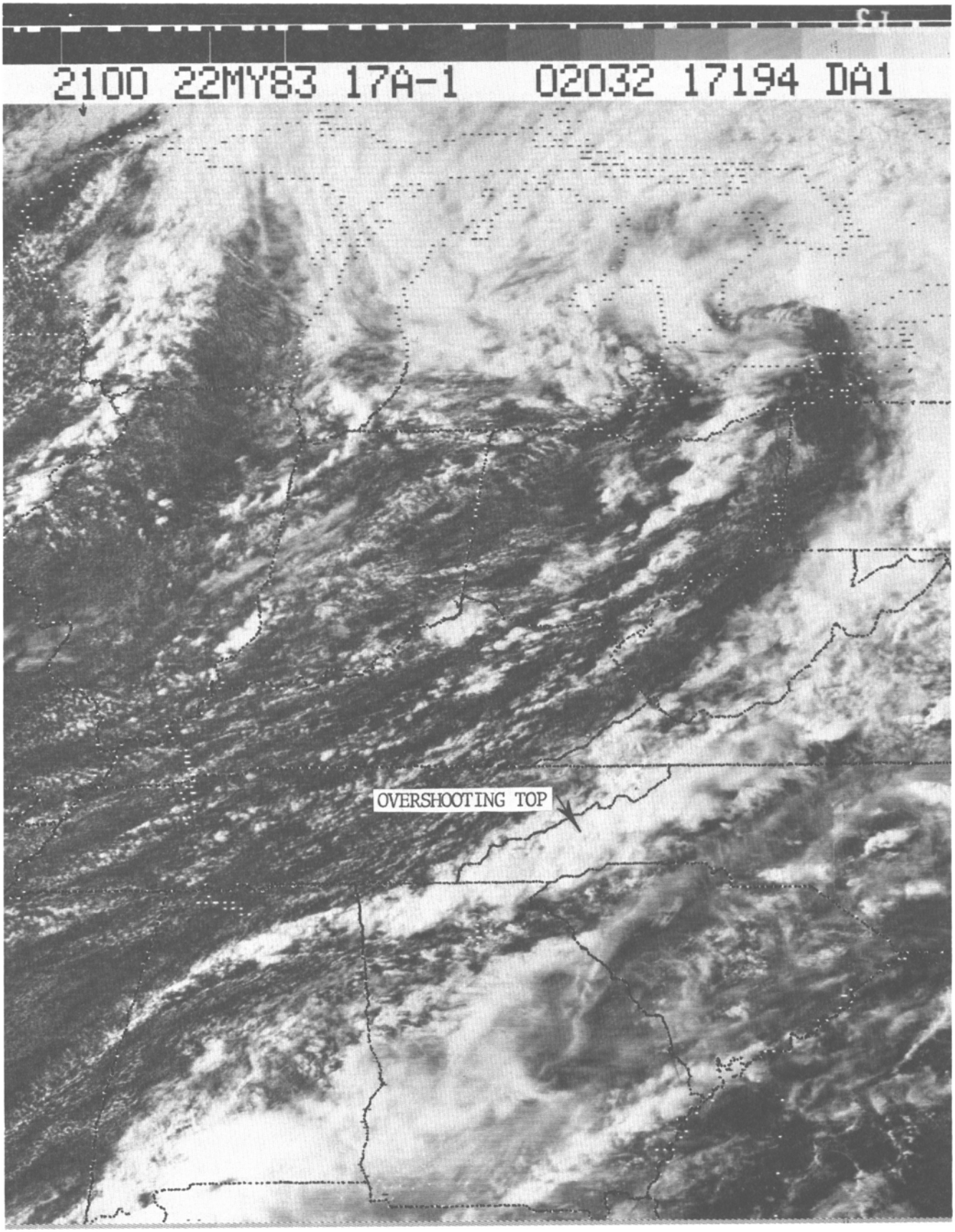

Figure 2. Goes-1 photograph for 1600 EST, May 22, 1983.

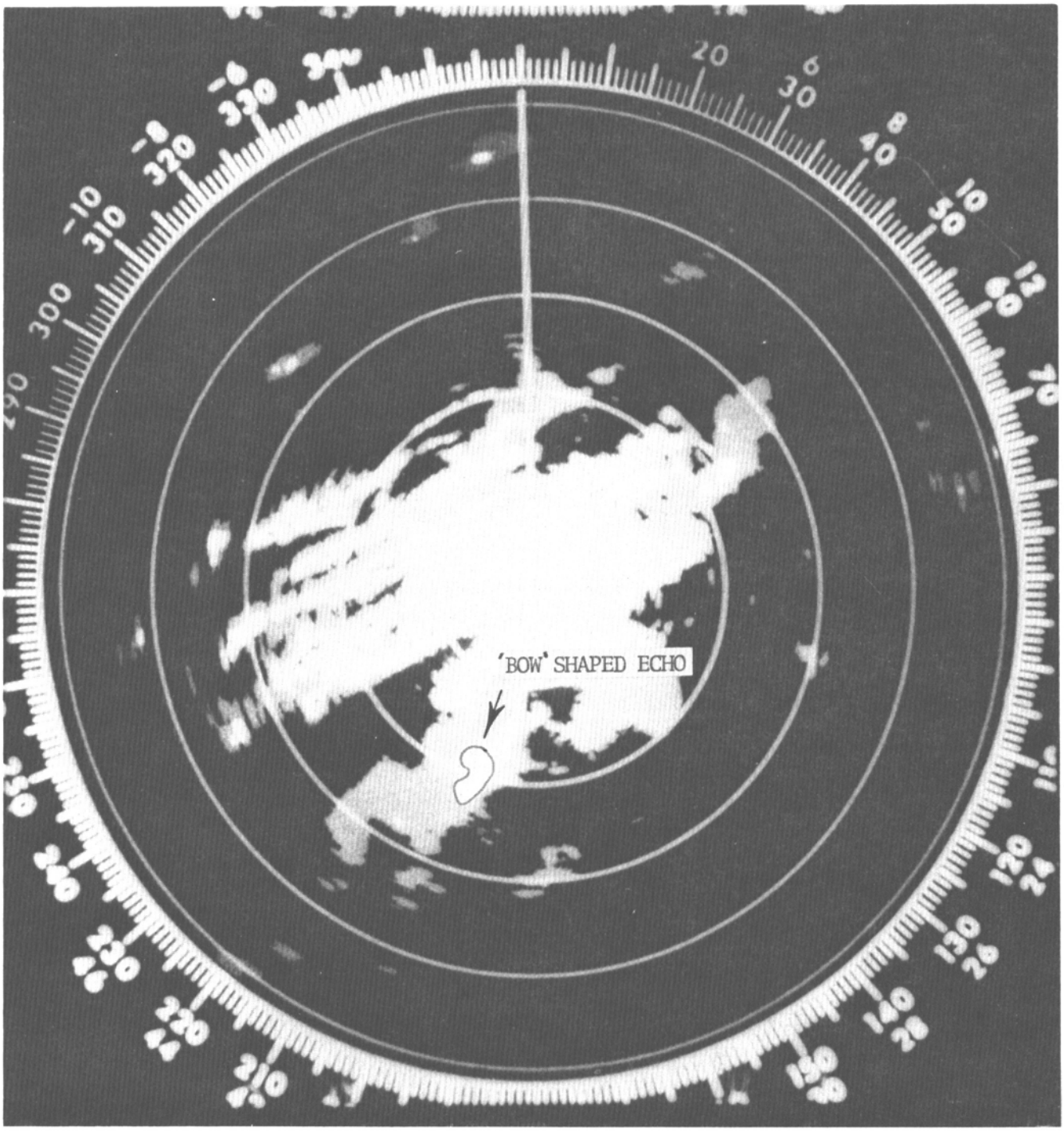

Figure 3. Bristol, TN radar photograph for 16:12 EST, May 22, 1983. "Bow" shaped cell outlined for clarity.

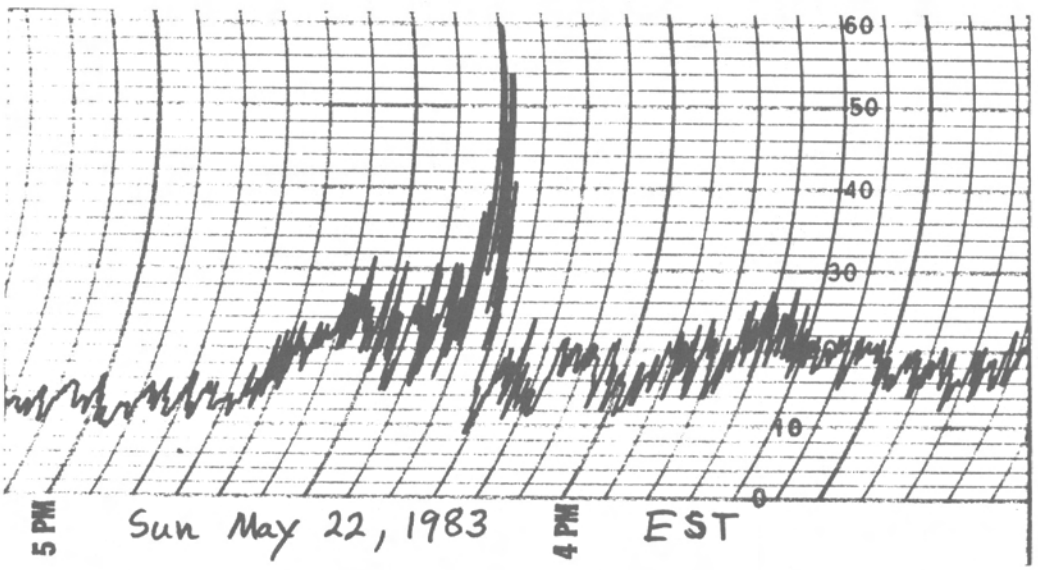

Figure 4. Wind gust record for Flat Top Mountain, N.C. May 22, 1983. Chart is calibrated in knots.

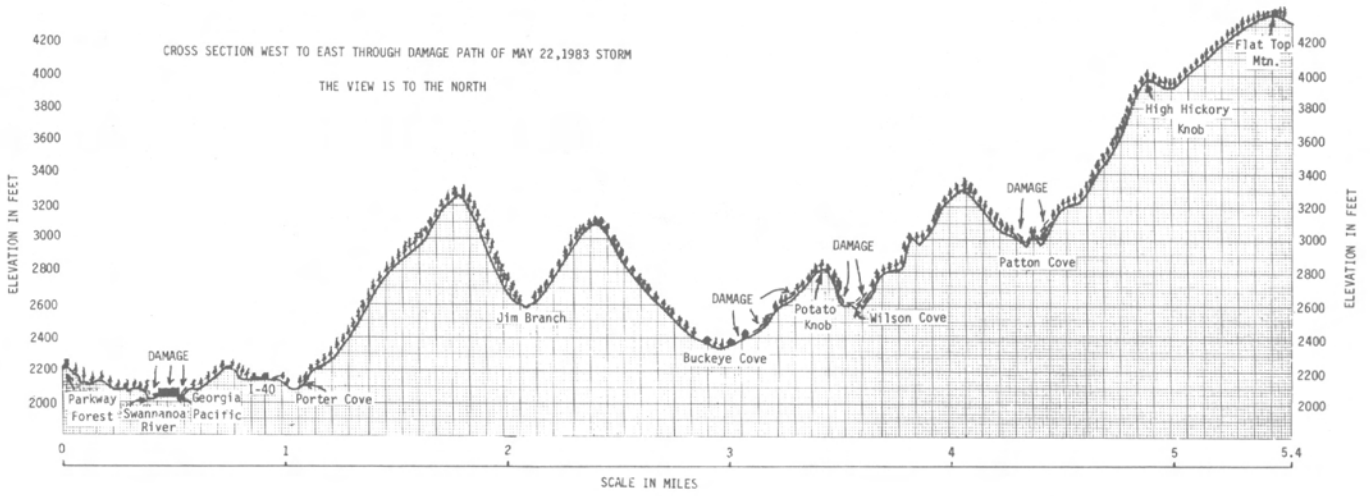

Figure 5. Cross section of terrain through the damaged areas. The view is to the north.

Figure 6. Aerial photograph of third "damage" area. The view is to the northwest. Photograph was taken from 300 feet above ground level.

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