Chapter 6

MESOSCALE ASPECTS OF NORTHEAST SNOWFALL DISTRIBUTION

The descriptions of 30 major Northeast snowstorms in chapters 3 and 4, and 37 “near miss” cases in chapter 5, provide a basis for understanding the evolution of the cyclones responsible for the heavy snow-producing systems in the Northeast, while describing atmospheric features and processes that operate on a continuum of scales from the very large, or synoptic scale, to very small, or mesoscale. The snowfall distributions exhibited by the many cases shown in Figs. 3-2, 5-5, and 5-13 cover large, synoptic-scale areas, but all contain mesoscale detail. Mesoscale regions of enhanced snowfall rates are often associated with snowbands that can occur within larger synoptic-scale areas of heavy snow or they can exist as isolated phenomena. These bands are often less than 100 km wide and can extend over lengths of several hundred kilometers, and in some cases, the bands may extend over lengths approaching 1000 km.

An example of distinct mesoscale structure within a synoptic-scale area of snow is shown in a visible satellite image of the mid-Atlantic states following the 31 March–1 April 1997 snowstorm (Fig. 6-1). This storm primarily affected southeastern New York and southern New England with very heavy snows (Fig. 6-1a; also see volume II, chapter 10.28). However, an area of heavier snow also fell across a very small portion of southeastern Pennsylvania, northeastern Maryland, and northern Delaware, as observed in the visible satellite image (Fig. 6-1b). The morning following the snowstorm, the town of Christiana in eastern Lancaster County, Pennsylvania, reported 18 in. (45 cm) of snow, while whatever snow that had fallen in western Lancaster County had already melted. The mesoscale structure noted for the April 1997 snowstorm can be found in virtually every case described throughout this monograph.

In this chapter, mesoscale characteristics of snowfall are addressed and related to features such as conditional symmetric instability and frontogenesis, inverted surface pressure troughs and other quasi-frontal boundaries, gravity waves, elevation, thundersnow, and “bay effect” or “ocean effect” snowfall. Storm Data and Climatological Data dating from 1960 to 1999 were examined to find cases, using a methodology similar to that described by Branick (1997), who examined winter storm events across the entire United States for a 12-yr period from 1982 to 1994.

Orlanski (1975) provides a basis for defining the scales of weather systems, which is shown in Fig. 6-2 to include Northeast snowstorms. Synoptic, or “macro β,” scales of motion cover distances between 2000 and 10 000 km and time periods of a day to several days. Mesoscale features are defined as spanning distances of 2–2000 km and time periods of 1 h to 1 day. Orlanski subdivides mesoscale into three subscales: meso-α (200–2000 km; around 1 day), meso-β (20–200 km; several hours to 1 day), and meso-γ (2–20 km; 30 min to a few hours). This chapter will examine the variety of mesoscale snowfall detail found within Northeast snowstorms, spanning the meso-α to meso-γ scales.

The development of narrow, singular, or multiple snowbands with meso-α to meso-γ scales remains a perilous prospect for forecasters and is rarely resolved by current operational models. When these historically unpredicted events affect a populated urban environment, such as the Northeast urban corridor, its societal and economic impacts are large, and public perceptions of forecast capability are severely affected. A statement released by the New York City forecast office following a mesoscale snow event that left up to a foot (30 cm) of snow over heavily populated regions of Long Island and western Connecticut on 13 December 1988 that was not predicted points to frustration associated with the forecast challenges that remain.

Events like this cause weather forecasters to lose their hair at an early age and in some cases to develop stomach ulcers. We have to admit the existence of many weather events that are...at this stage of our weather science...unforecastable. There are situations that slip between the cracks and I am afraid this has been one of them. We missed it and so did the computers. We could only sit here at the Weather Service Office and watch the situation go from bad to worse. We became observers as opposed to forecasters.

1. Examples of snowbands with possible linkage to midlevel frontogenesis and symmetric stability

The roles of moist symmetric stability and frontogenesis in the development of precipitation bands have been described in numerous articles over the past two decades (Bennetts and Hoskins, 1979; Emanuel 1979, 1983, 1985; Sanders and Bosart 1985a; Sanders 1986b;
Wolfsberg et al. 1986; Nicosia and Grumm 1999; Graves et al. 2003). From these studies, a relationship between frontogenesis and symmetric stability can be applied to describe the narrow regions of ascent that lead to the banded structure often observed with snowfall. The ascent regions are enhanced and contracted to meso-α and meso-γ scales when the symmetric stability is low and where the frontogenesis is maximized. Nicosia and Grumm (1999) examine heavy snowbands located along the northwestern edge of the synoptic-scale snowband for several recent snow events in the eastern United States, including the cases of 3–4 February 1995 (see volume II, chapter 10.26), 19–20 November 1995, 3–4 March 1994 (also see volume II, chapter 11.1), and 12 January 1996 (Fig. 6-3). The snowbands are often west of the heaviest precipitation predicted by current numerical models but occur near model-forecast frontogenesis at 700 hPa. The frontogenesis process is enhanced as a midtropospheric low develops and intensifies (as the cyclonic circulation extends upward during cyclogenesis) and as the exit region of an upper-level jet streak/dry intrusion encounters the region.

The Next-Generation Doppler Radar (NEXRAD) imagery for cases provided by Nicosia and Grumm (1999) and Graves et al. (2003) shows that the development of one or more snowbands are often embedded within a larger synoptic-scale region of snow. These bands are typically oriented from southwest to northeast and appear to move slowly northeastward, or to remain stationary and “pivot” slowly in a counterclockwise direction as individual radar elements merge into the band from the east, southeast, or northeast.

A series of images from the 25 January 2000 snowstorm in Washington, D.C., illustrates the banded struc-