Mid-Atlantic and Northeast U.S. Winter Storm
January 26-27, 2011
By: Dave Hamrick, HPC Meteorologist

<u>Overview</u>: A two-part winter storm brought heavy snowfall to parts of the Mid-Atlantic region and into the Northeast United States from the morning of January 26 to the afternoon of January 27, 2011. The first round of wintry weather from northern Maryland to southern New England was associated with a moderately strong coastal low pressure system that was analyzed at 997mb on the 18Z surface analysis for January 26. Several inches of snow fell in these areas. This slowly deepened to a 978mb occluded low just east of Nova Scotia by 18Z on January 27, but the main precipitation shield with this oceanic low was well offshore from the U.S. waters by that time.

It was the second round of wintry weather that made most of the headlines. This was associated with a deep upper-level low that progressed from the central Appalachians and eventually over southern New England, and had a rich supply of moisture from the Atlantic Ocean. Unlike the first round of snow, this second system had steeper lapse rates and this allowed strong deep layered ascent to develop. Thunder and lightning was observed within some of the heaviest snow bands. Cooling from the ascent allowed rain to rapidly change to sleet and then snow over much of the Mid-Atlantic by the evening of the 26th. This changeover occurred during the evening rush hour in the D.C. metro area, causing crippling traffic delays (Fig. 1a). Periods of heavy snow continued through the overnight hours and into the morning of the 27th as the system progressed over the New York City metro area and finally exited eastern Maine. Snow to liquid ratios were considerably lower than average with values near 6:1 in the Washington, DC area, and slightly higher over New England where colder air was in place. The density of this snow weighed heavily on trees and other elevated surfaces, leading to massive power outages during and immediately after the storm (Fig. 1b). Storm total snowfall approached 20 inches in New York City (Fig. 2), allowing the city to break the January record for monthly snowfall.

Fig. 1a. Traffic gridlock on the roadways of the greater DC area. Photo courtesy of www.freerepublic.com

Fig. 1b. The heavy, wet snow creates a winter wonderland in central Maryland. Photo courtesy of FEMA.

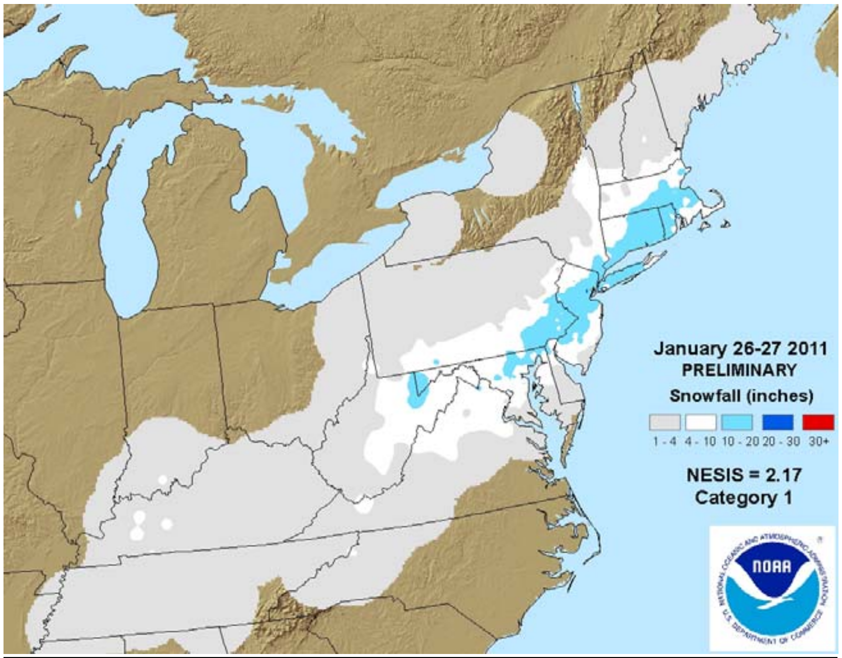

Fig. 2. NCDC map of snowfall totals with this event.

Synoptic Environment: The 00Z surface analysis on January 26 (Fig. 3a) showed a weak stationary front stretching from the southern offshore waters of Nova Scotia to the Georgia coast, which eventually served as a source of vorticity for the surface low that developed. The southern extent of this feature was a coastal front that had formed near the North Carolina and South Carolina coastline, and it was here that the surface low developed around 12Z on the 26th (Fig. 3b). A surface warm front extended to the northeast from this low, and the snow that fell on the morning of the 26th was largely a result of isentropic upglide on the north side of that front. A ridge of Canadian high pressure from Quebec ensured the presence of enough cold air for wintry precipitation.

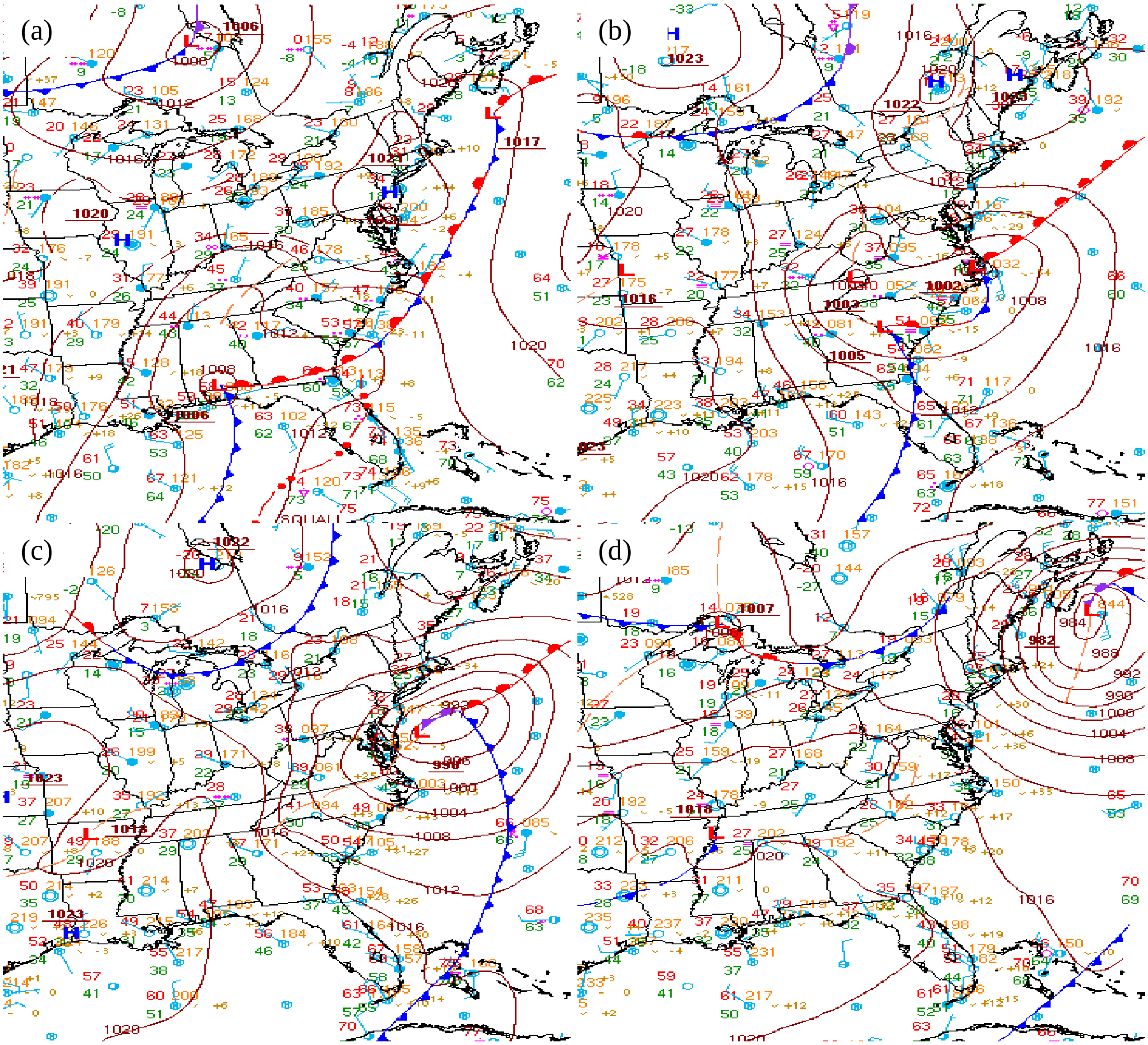

Fig. 3. Surface Analyses from the Hydrometeorological Prediction Center at (a) 00Z 26 January, (b) 12Z 26 January, (c) 00Z 27 January, and (d) 12Z 27 January.

By 12Z on January 25th, a pronounced positively tilted trough was evident in the 500mb height pattern over the Central Plains (not shown). At the same time, a distinct trough was also noted in the 250mb height pattern in the same general area, with the jet maximum over West Virginia and Virginia. The upper low moved from near Memphis, TN at 6Z January 26th, to 100 miles southeast of Cape Cod, MA by 12Z January 27th (Fig. 4a-4f). This upper-level low had a closed 700mb height contour of 2910m beginning at 12Z on the 26th over eastern Tennessee, and had a closed 2850m height contour by 00Z on the 27th over the Chesapeake Bay (Fig. 5c). At 250mb, the axis of jet stream had shifted to eastern New England by 12Z on the 26th, placing the development of the surface low in the favorable right entrance region of the jet. However, by early on the 27th (Fig. 5a) the jet stream had shifted far enough offshore to make mid-level processes more dominant in generating deep layered ascent near the upper low. By the end of the day on the 27th, the upper-level low merged with the coastal low near Nova Scotia.

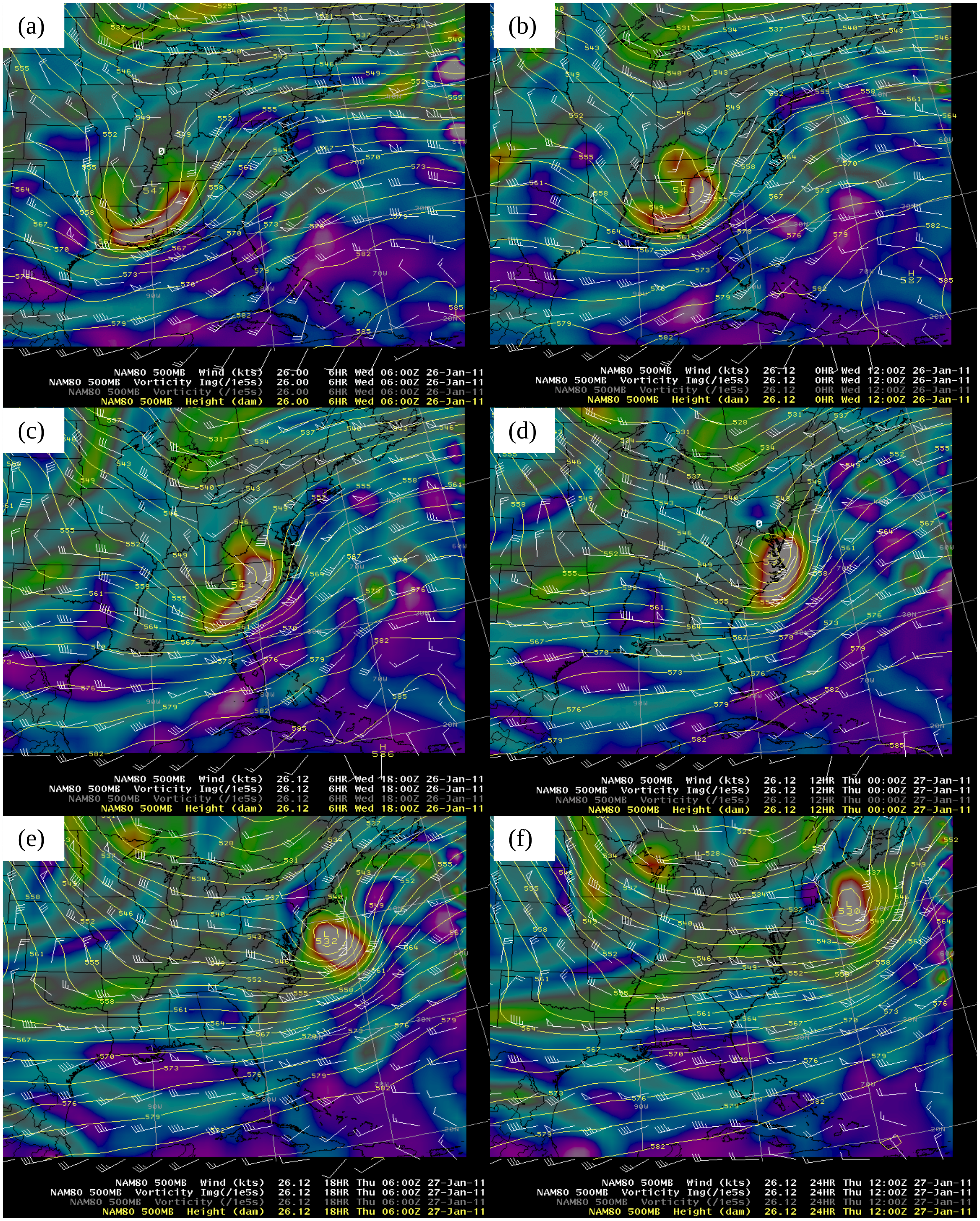

Fig. 4. NAM model depictions from AWIPS of the 500mb pattern with wind speed and direction denoted with wind barbs, the lines showing height field, and vorticity as an image with the red and white colors indicating the greatest positive vorticity. Fields shown at (a) 06Z 26 January, (b) 12Z 26 January, (c) 18Z 26 January, (d) 00Z 27 January, (e) 06Z 27 January, and (f) 12Z 27 January.

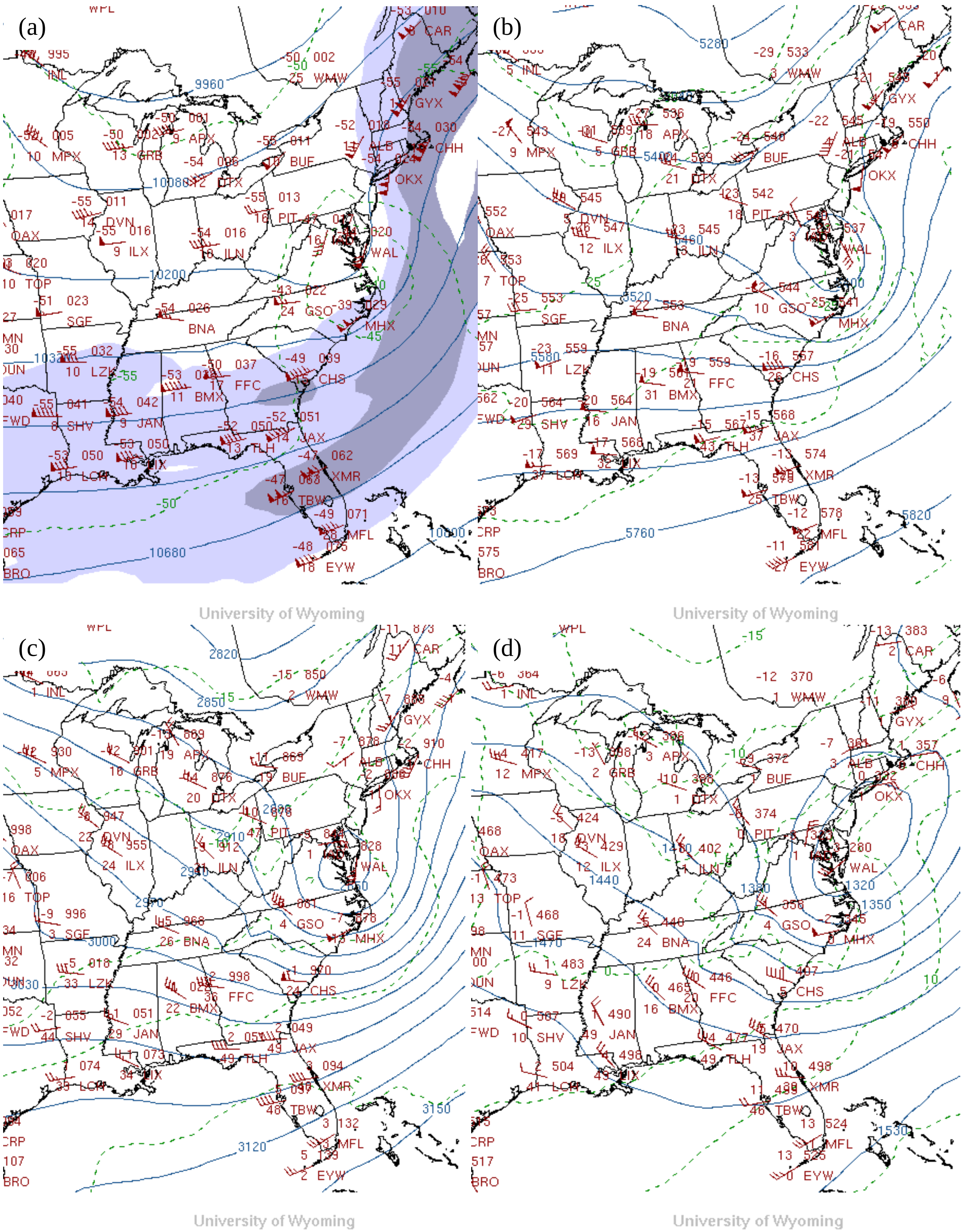

Fig. 5. These graphics show the overall structure of the troposphere at the height of the event at 00Z on January 27. Analyses shown are (a) 250mb, (b) 500mb, (c) 700mb, and (d) 850mb. It is evident that the center of the upper low at this time is displaced about 100 miles to the west of the surface low, and is in the process of merging with the surface low. Images courtesy of the University of Wyoming.

Mesoscale Processes: The snow from the first round was confined to areas north and east of Washington, and ranged from a dusting to six inches. The first round of precipitation in the Northeast U.S. from the offshore surface cyclone contained mainly snow over inland parts of New Jersey, New York, Connecticut, Rhode Island, and Massachusetts. Along the coast and over Long Island, boundary layer temperatures were slightly warmer and allowed some sleet and freezing rain to mix in with the snow. The presence of northeasterly winds at the surface maintained a fresh supply of near freezing or sub-freezing temperatures where the precipitation was falling. According to radar imagery, this round had more variations in the snowfall intensity and did not cover as large of an area as the second round (Fig. 6a). As stated previously, the majority of the snowfall with this system occurred with the second round of precipitation associated with the passage of the upper-level low (Fig. 6b). This was a relatively brief but heavy round of snow that resulted in snowfall rates up to three inches per hour at times. On the two radar images below, there are more dark green and yellow colors, corresponding to higher dBZ values and thus heavier precipitation rates, with the second round depicted on the right.

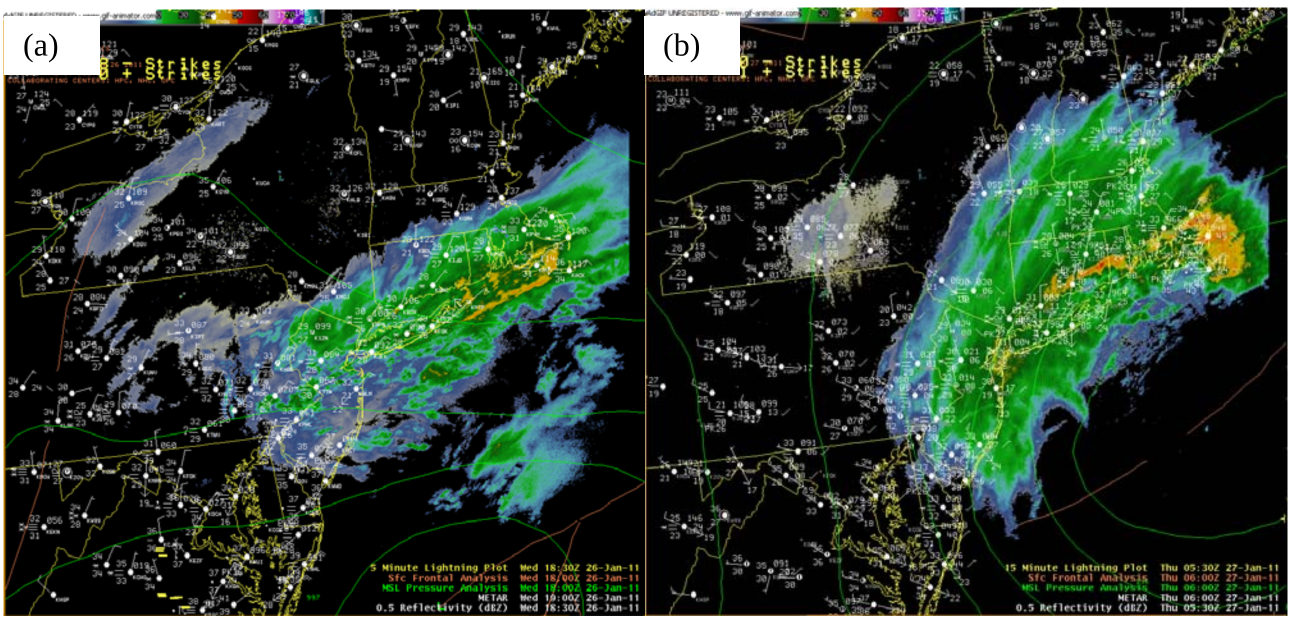

Fig. 6. Radar imagery over southern New England, with (a) indicating precipitation with the first round, and (b) indicating precipitation with the second round.

The leading edge of the heavy precipitation during the second round initially began as a period of moderate rain with embedded thunderstorms before transitioning to heavy snow. Given the steep mid-level lapse rates near the leading edge of the 500mb low, convective activity developed over northern Alabama during the morning hours of January 26th, and moved into Virginia by the afternoon (Fig. 7a). Precipitation developed in an area of intense positive vorticity advection ahead of the upper low and in an environment of instability. The precipitation transitioned from rain to thundersleet and thundersnow during the Washington, D.C. evening commute (Fig. 8), causing crippling traffic jams. The image at 2138Z (Fig. 8c) was a transitional period with heavy snow from Washington, DC and points west, and heavy rain and sleet to the east.

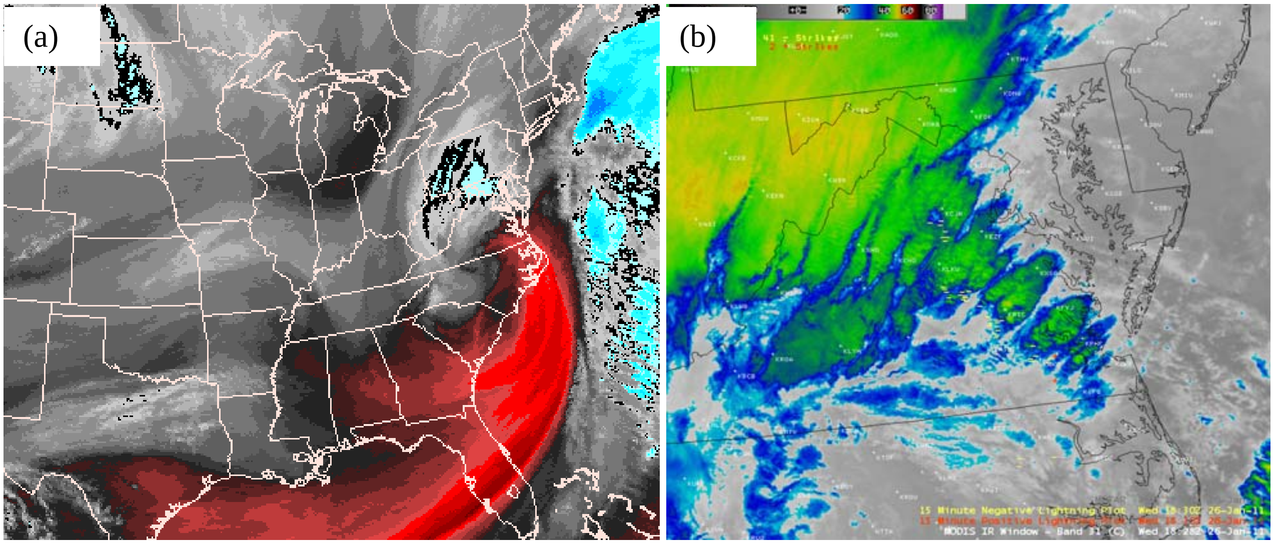

Fig. 7. Panel (a) is water vapor imagery valid at 2045Z. The image in panel (b) is a higher resolution enhanced infrared image at 1828Z over the Mid-Atlantic region, showing the convective nature of the cloud band pivoting north through central Virginia, along with lightning data.

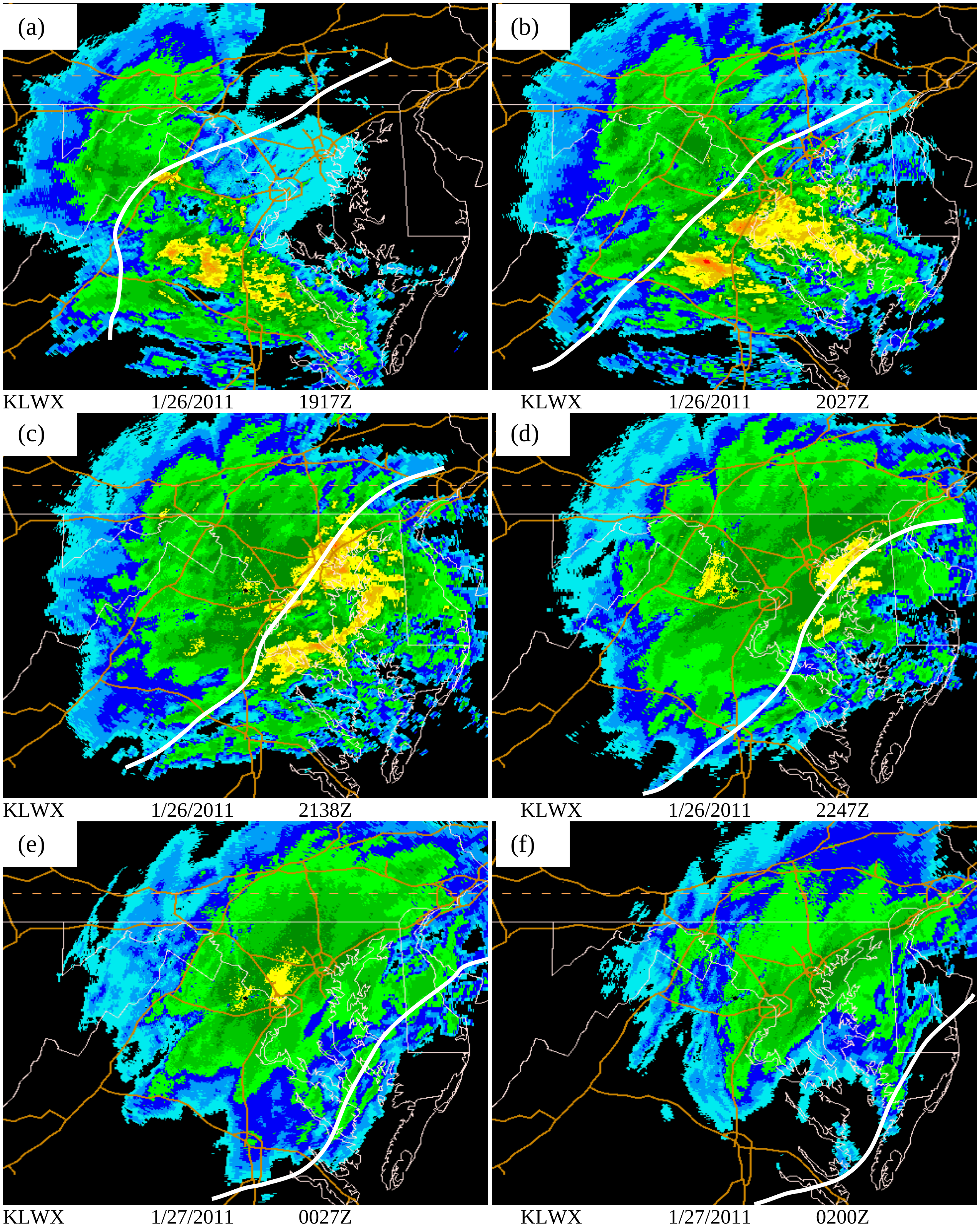

Fig. 8. Radar images from NWS Sterling showing the evolution of the heavy precipitation in the Mid-Atlantic at (a) 1917Z 26 January, (b) 2027Z 26 January, (c) 2138Z 26 January, (d) 2247Z 26 January, (e) 0027Z 27 January, and (f) 0200Z 27 January. The heavy white line shows the approximate rain/snow boundary.

Another notable aspect of the storm was the amount of lightning activity. A significant period of thundersleet and thundersnow was observed over parts of the northern Mid-Atlantic, and a few rumbles of thunder over the Northeast U.S. as significant charge separation occurred owing to the strong vertical motions in place (Fig. 9).

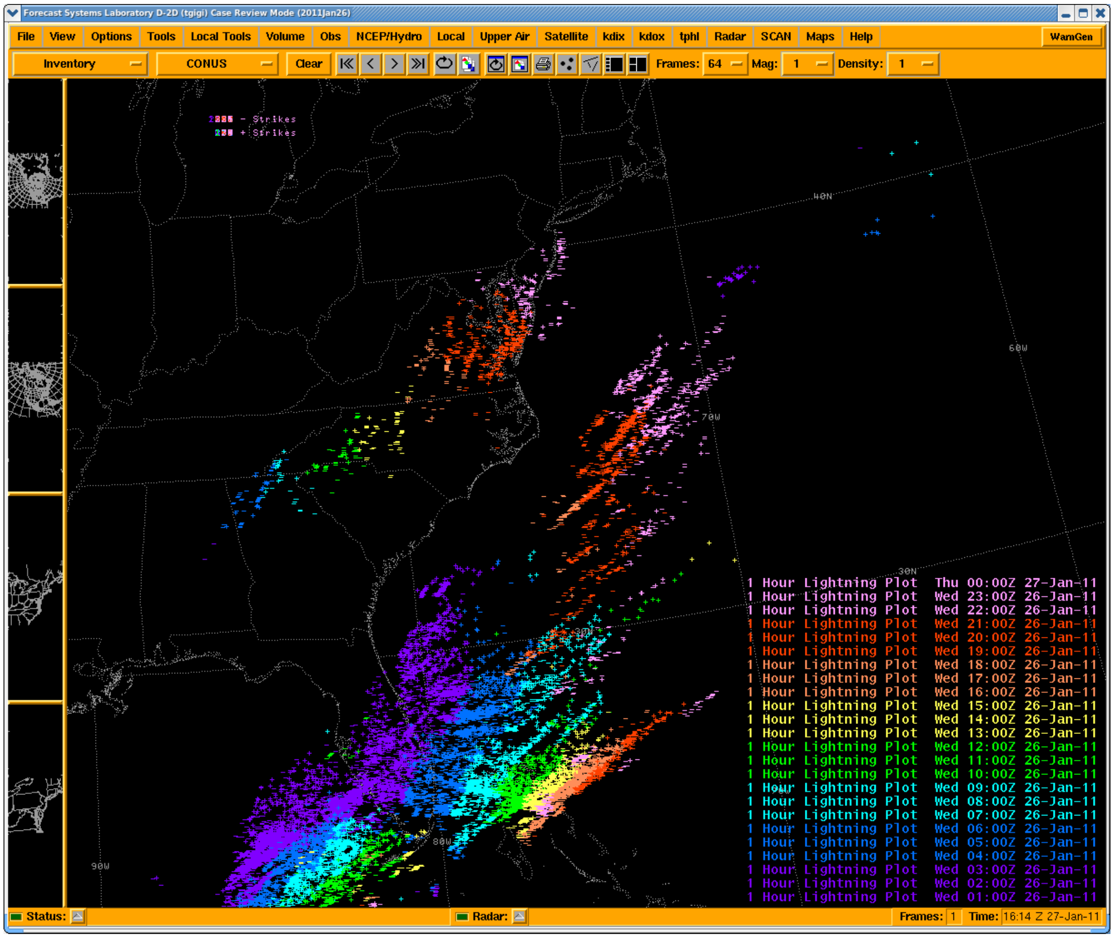

Fig. 9. This AWIPS display shows the extent of the cloud-to-ground lightning activity (color-coded by hour) that occurred with this event. The majority of the lightning was well offshore near the Bahamas and over the Gulf Stream waters in a much warmer airmass. The lightning with the upper-level low began over northeastern Alabama and continued over central Virginia and into New Jersey. There were also intra-cloud discharges that are not shown here.

The damaging nature of the storm was due in part to the very dense snow. Snow-to-liquid ratios were near 6:1 in the Washington, DC area, and slightly higher over New England where colder air was in place. The snow weighed heavily on trees and other elevated surfaces, leading to massive power outages during and immediately after the storm. Figure 10 shows two soundings around the times of heaviest snow for both Sterling, VA (Washington, DC area) and for Upton, NY (Long Island, NY area). Note the deep layer of near saturation in both of these soundings, and also the isothermal layer just below freezing in the boundary layer, resulting in the low snow to liquid ratios.

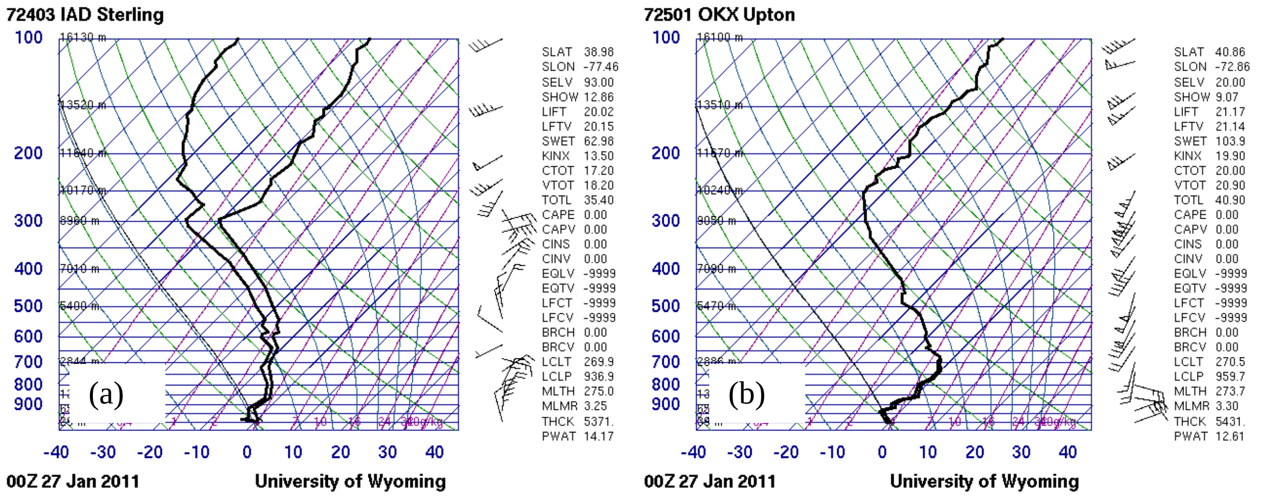

Fig. 10. Here are two soundings around the times of heaviest snow for both Sterling, VA (Washington, DC area) and for Upton, NY (Long Island, NY area). Note the deep layer of near saturation in both of these soundings, and also the isothermal layer just below freezing in the boundary layer, resulting in the low snow to liquid ratios.

<u>Conclusion</u>: This snow event was one of several significant winter storms to affect the East Coast during the active winter season of 2010-2011. Although it will not go down in history as the biggest snowstorm of all time, it will be remembered by many people for the severe travel disruptions it caused. This especially holds true for the now infamous evening commute in the Washington, D.C. area during the afternoon and evening of January 26th. As the dynamic cooling from the upper low moved closer to this area, the rain quickly changed over to sleet and then heavy snow during the height of the evening commute, stranding thousands of people on the roads for hours (some for more than 10 hours)! Another thing that made the event memorable was the occurrence of lightning while heavy snow was falling. A total of 19 inches of snow fell in New York's Central Park, allowing the city to set a record monthly snowfall for January.

For cities to the northeast, the heaviest snow came after the evening rush hour was over, and not as much travel chaos out on the roads. However, heavier snow fell in the Northeast U.S. and this severely affected air and ground travel. Many area schools and businesses were closed for at least a day following the storm.