Summary of January 22-23, 2016 Major Winter Storm over the Blacksburg, VA NWS Forecast Office Area

Overview

A classic set-up for a major winter storm to impact the mid-Atlantic region of the U.S. was generally well forecast several days in advance by most large scale prediction models used by the National Weather Service. The system was correctly forecast to develop near the Gulf Coast, with cold Canadian air already in place over the mid-Atlantic and Appalachian region, and move up into the southern Appalachians, and then re-form closer to the coast and strengthen rapidly while very slowly moving northeast up the coast. This track was conducive to pulling in abundant Gulf and Atlantic moisture into the region, along with the lift and duration necessary for significant amounts of snow, sleet, and freezing rain (depending on the temperature profile in the lower levels). In addition, the strong gradients across the area with deepening low pressure just off the coast were expected to result in gusty northeast to north winds causing snow to blow and drift as it fell. The primary uncertainty going into the event was not whether all 40 counties across the Blacksburg NWS forecast area would reach warning criteria snowfall, but just how extreme the amounts would be.

What transpired was reasonably close to what was forecast, with a major snowstorm for our entire region, which also included a mix of some sleet across portions of the area as well as small amounts of freezing rain across the NC Piedmont. Farther south across the Carolinas, more ice and sleet occurred compared to snow. North of our area, however, was under the bullseye of the heaviest snowfall, from northern VA and the panhandles of WV and MD, northeastward to the New York City area, where historic amounts of snow fell (much of it blowing and drifting). Figure 1 below shows a regional summary of the snowfall totals across the eastern U.S., with maximum amounts of 30 to 42 inches near the VA/WV/MD border area. In our forecast area, much of the western and northern portions picked up 12-20” of snow, with 6-12” in the Piedmont areas.

NOAA ranks Northeast U.S. storms according to overall impact, part of which is dependent on societal and economic factors, thus population density is a key component. This particular storm was ranked as a 4 on the “NESIS” scale of 1-5, or “crippling”. It is now 4th on the list of historic storms that have been ranked on this scale, with only two storms ever ranked as a 5 (“extreme): March 12-14 1993 and Jan 6-8 1996. For more information on the NESIS ranking system, see this site: http://www.ncdc.noaa.gov/snow-and-ice/rsi/nesis

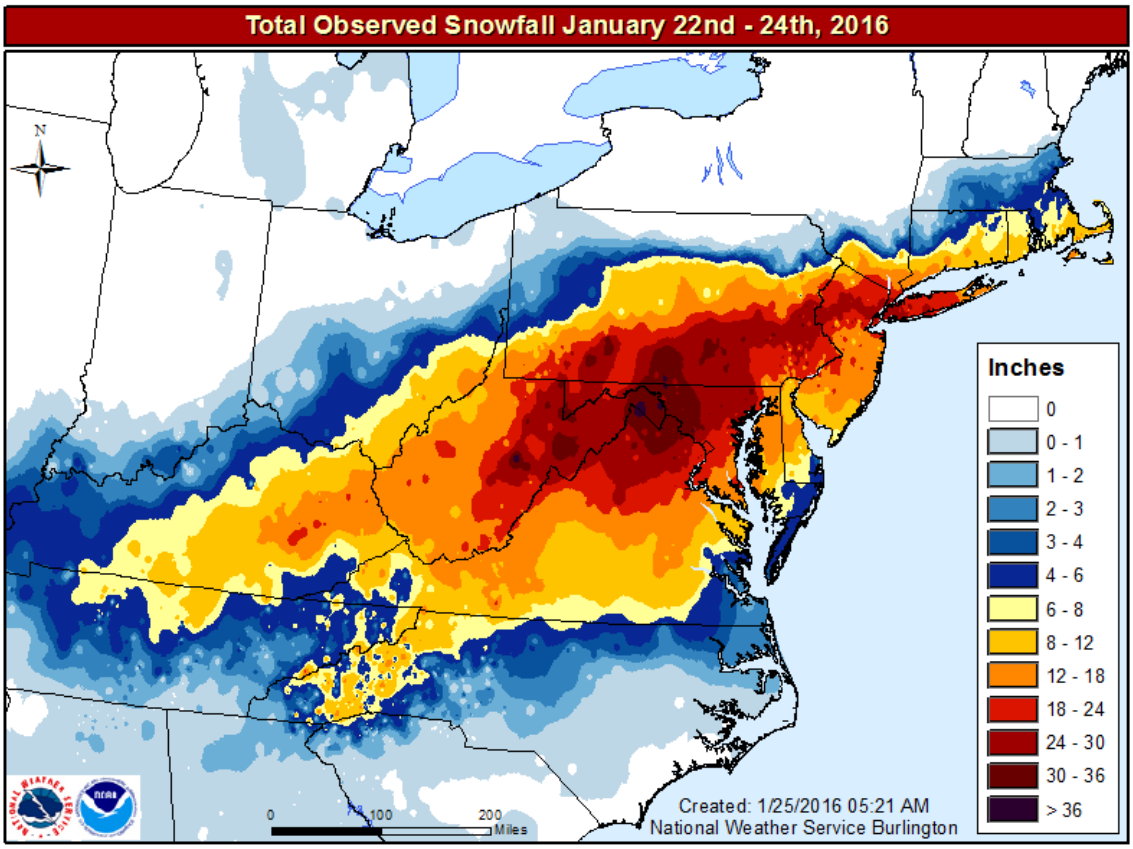


Fig. 1. Regional snow totals for the Jan 22-24, 2016 storm.

Figure 2 below is a high resolution satellite picture from a mosaic of polar orbiter images taken from NASA's "Terra" satellite, and dramatically shows the coverage of snow from as far south as northern Alabama and upstate South Carolina all the way up into southern New England. The whitest areas are larger valleys (such as the Shenandoah Valley) that have much less forest cover than most other locations where many types of trees partially block the view of the snow-covered ground.

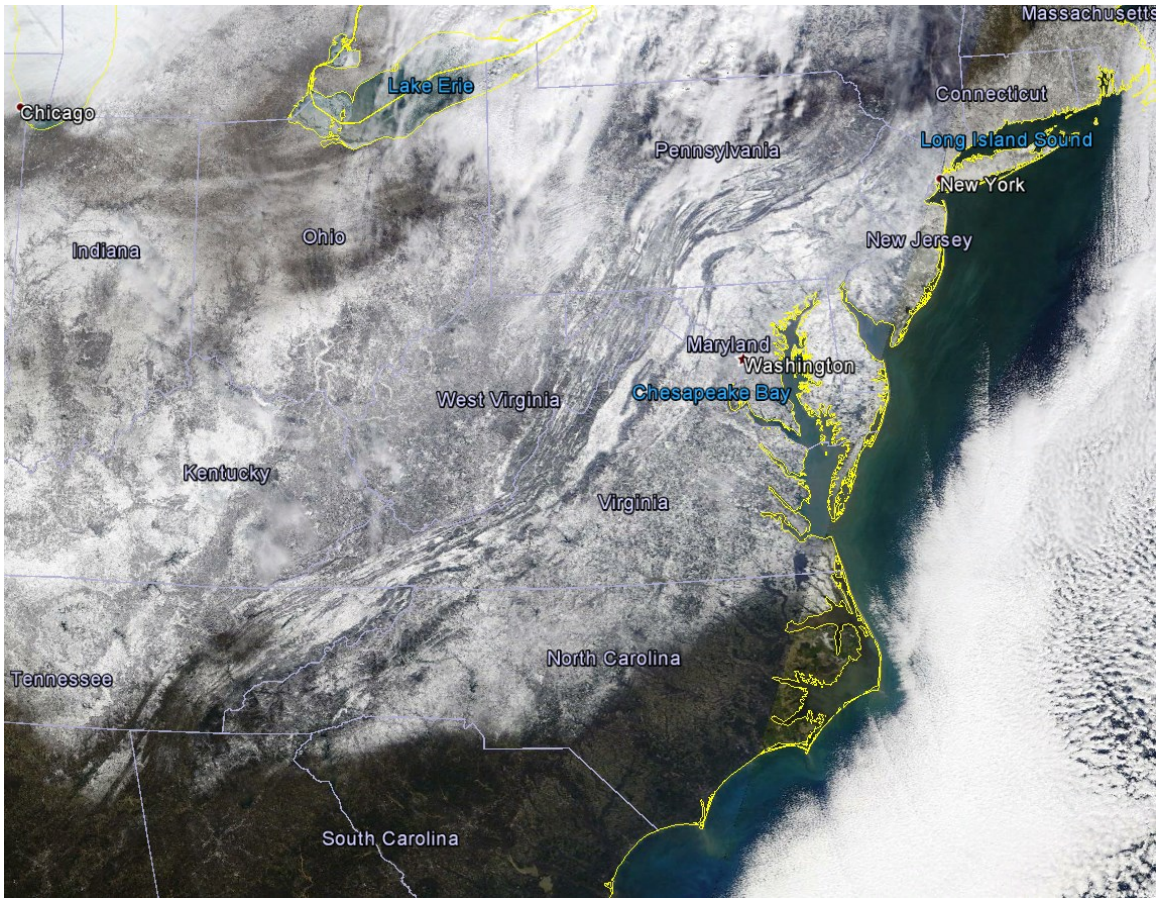


Fig. 2. Satellite visible view from "MODIS" instrument on board NASA polar orbiting "Terra" satellite, showing the snow cover the day after the event ended (Jan 24).

The series of images below (one on each page) show the evolution of the storm system from the track of the low pressure (with isobars – lines of constant pressure) and radar data overlaid. Each image is 12 hours apart, and the sequence runs from 0600 UTC January 22 (1:00 am), about when snow began across northwest NC (Figure 3), through 0600 UTC Jan 24 (1:00 am) when the snow had tapered off across western Virginia but was still falling along parts of the mid-Atlantic coastal areas (Figure 7). Notice the transition from when the initial low center is taken over by the coastal low late Friday and Friday night (Figures 4 and 5), during which time there were breaks in the heavier accumulations across much of our area, with a transition to sleet in some areas as a warm nose of air moved in just above the surface. This is considered a "Miller B" pattern for coastal storm development (as opposed to Miller A where no transition takes place and the main low simply track from the Gulf up along the Atlantic coast while strengthening). After the new coastal low took over from the

weakening original low center, colder air moved back in behind this new low, with bands of snow developing again on the back side of the system. This allowed the western and northern parts of our area to pick up several more inches into Saturday Jan. 22nd.

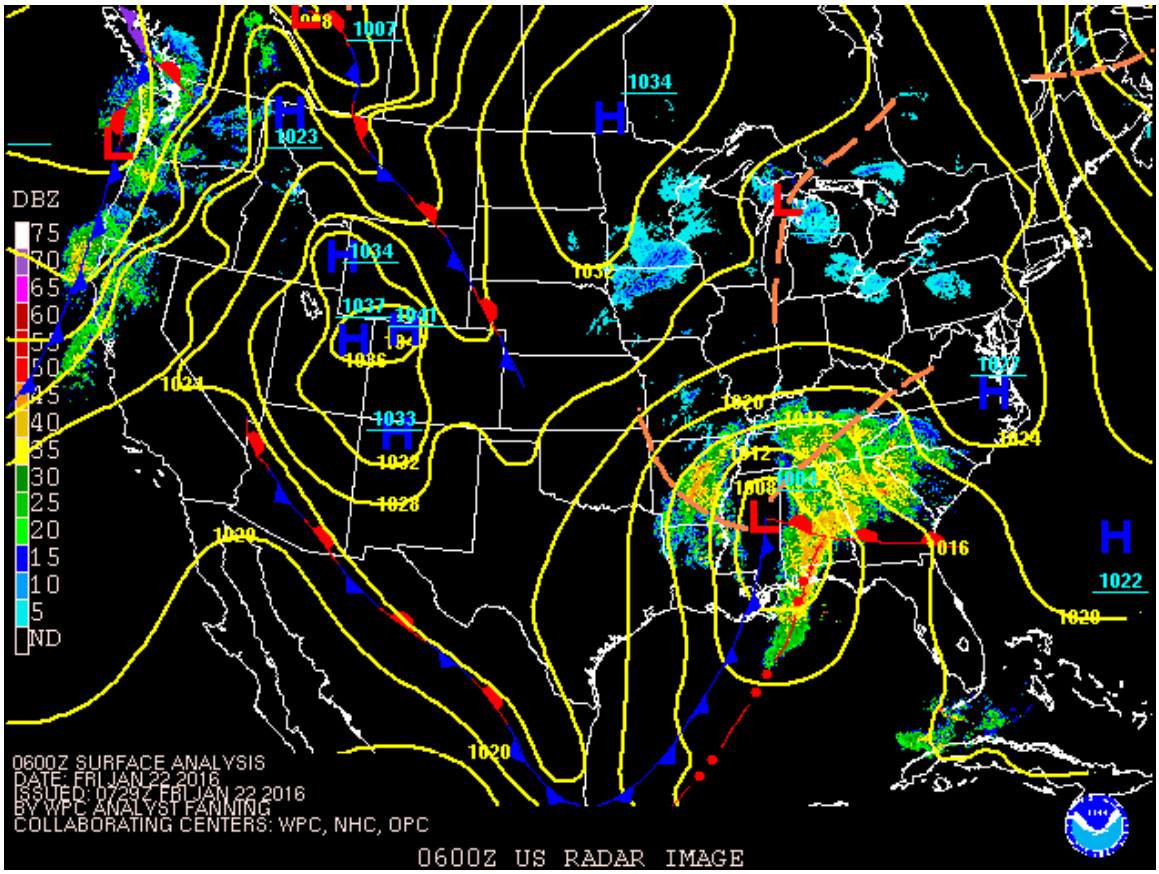


Fig. 3. Surface map and radar at 1:00am Friday Jan 22, 2016.

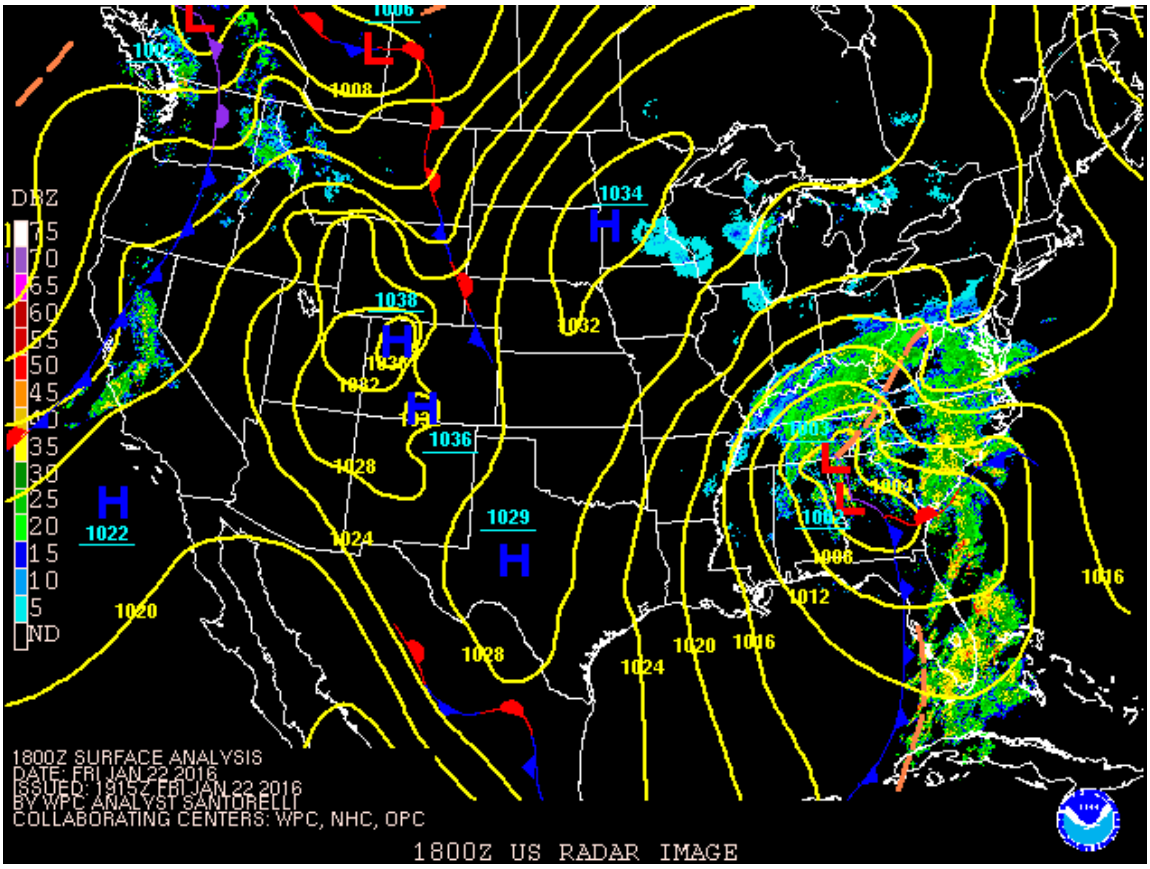


Fig. 4. Surface map and radar at 1:00pm Friday Jan 22, 2016.

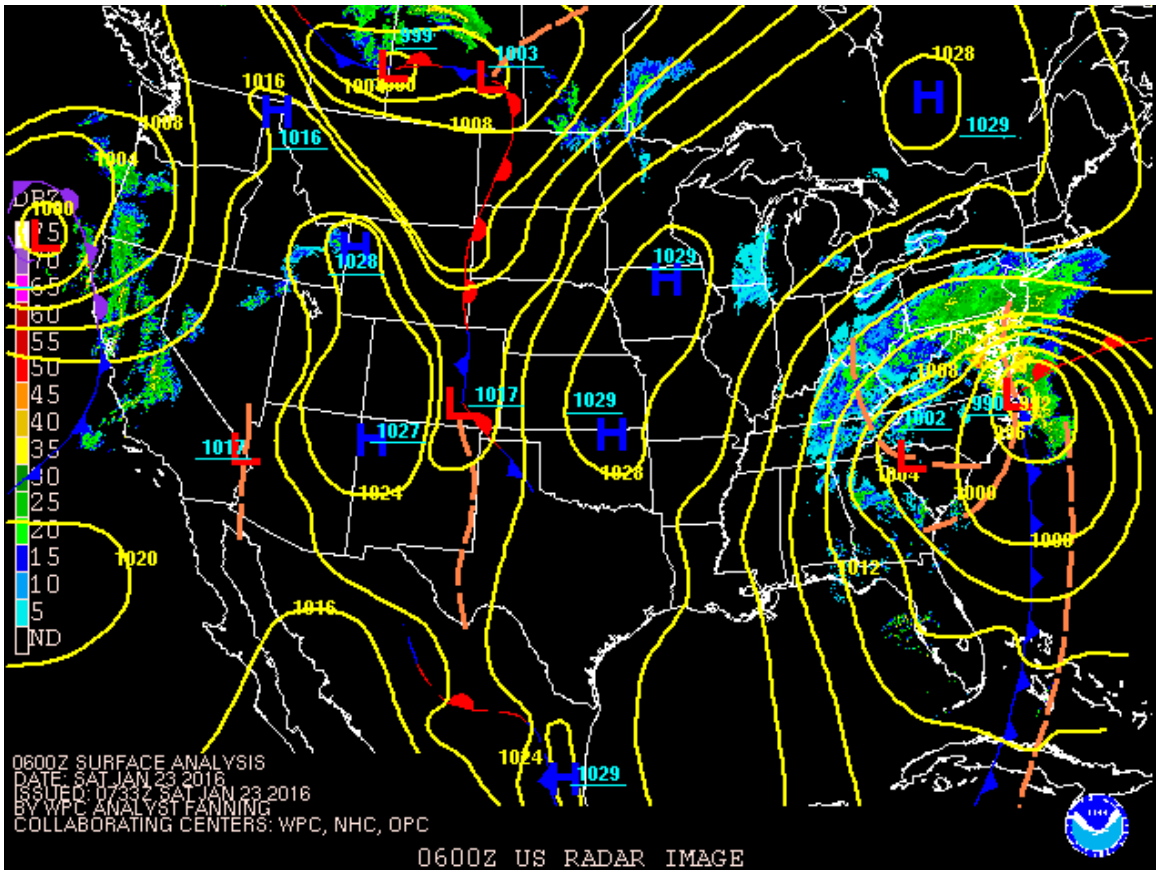


Fig. 5. Surface map and radar at 1:00am Saturday Jan 23, 2016.

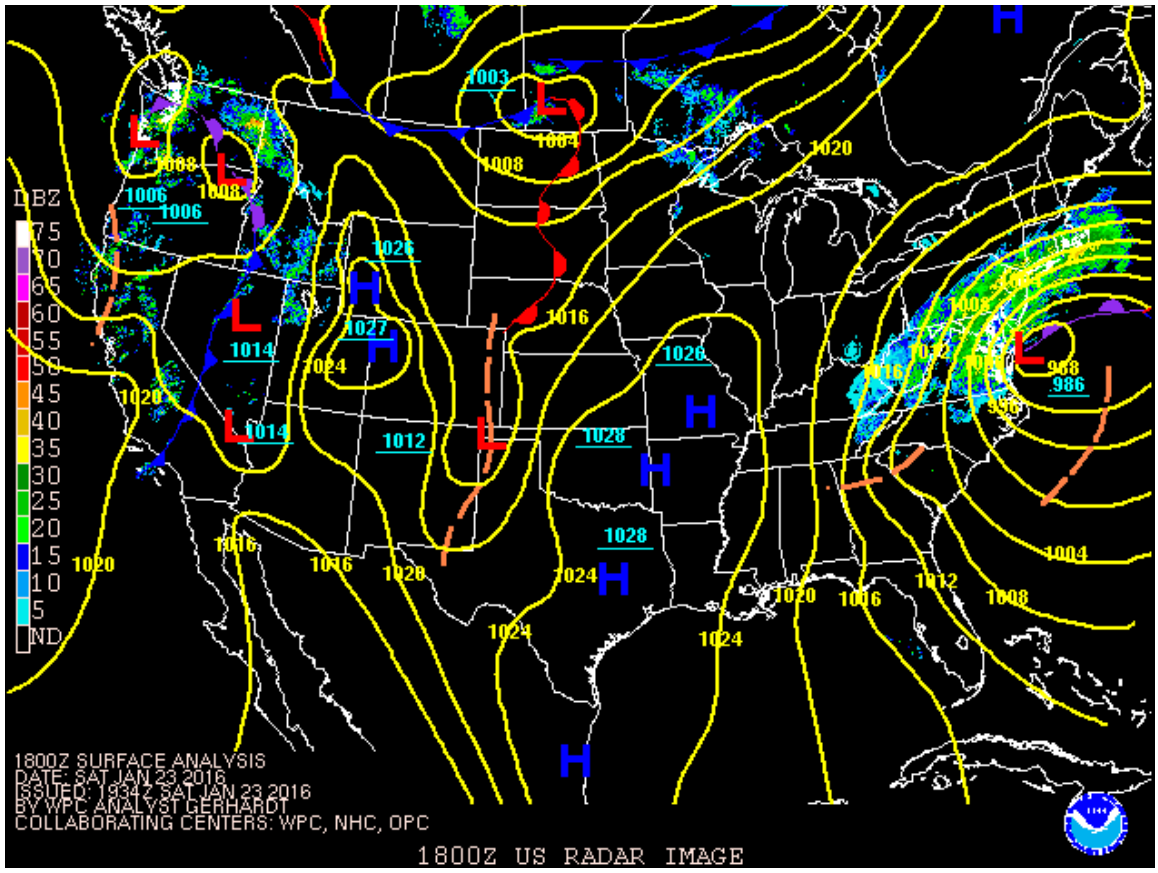


Fig. 6. Surface map and radar at 1:00pm Saturday Jan 23, 2016.

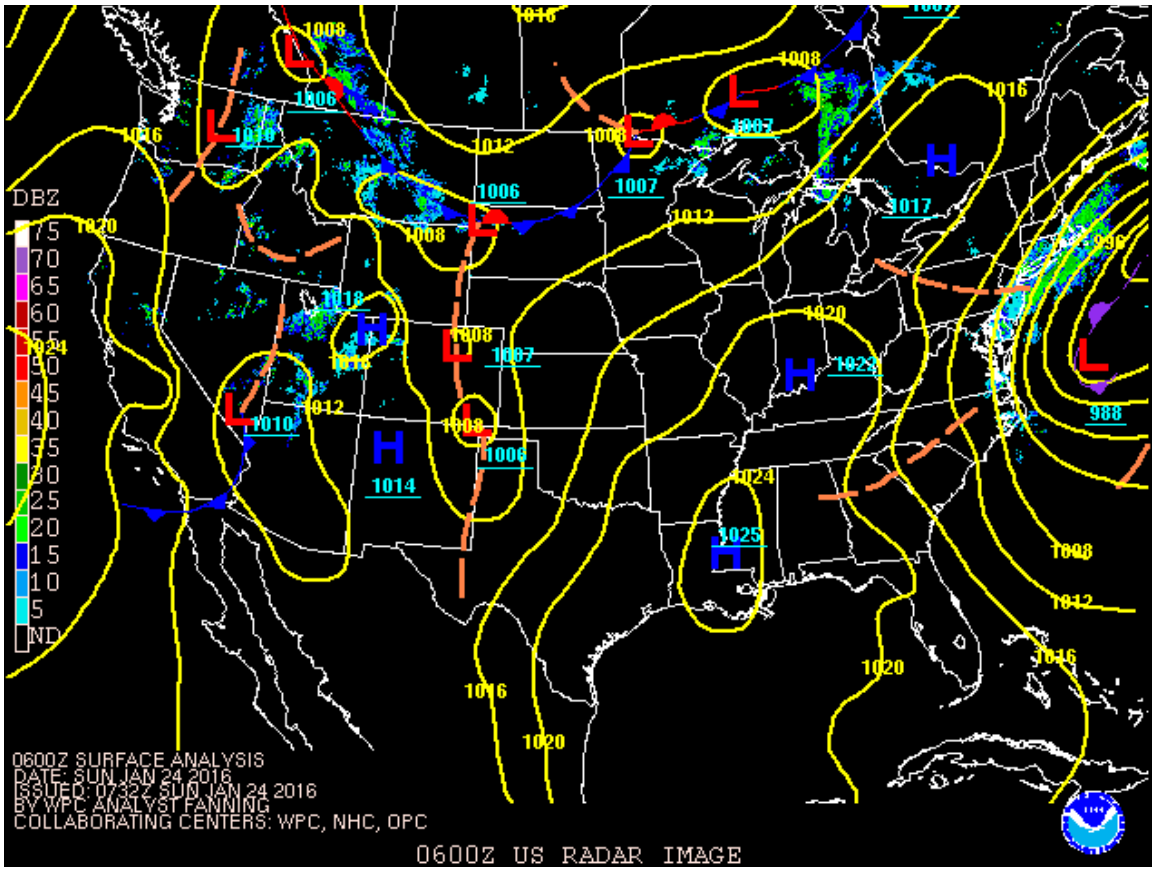


Fig. 7. Surface map and radar at 1:00am Sunday Jan 24, 2016.

Forecast challenges remained leading up to start of event

While the forecast for a winter storm meeting at least minimal warning criteria for snow (5" in the west and 4" east of the Blue Ridge) was nearly a meteorological "slam dunk", there was still some question as to just how much precipitation would occur, partly dependent on how quickly the storm would strengthen and pull in moisture from the oceans, how slowly it would move, and exactly where the zone of stronger lift would take place. The question of a "dry slot" of air moving in over parts of the area during the transition phase also arose (some models suggested it, others did not), and there were also differences in how strong the layer of relatively warm air aloft would be (possibly resulting in precipitation falling as sleet or freezing rain for some locations, mainly across our southern flank. These can all be very difficult factors to pin down much more than 12-24 hours in advance, and many of the model solutions showed a large spread in these outcomes of total snowfall expected because of this.

To illustrate this challenge, shown below are some ensemble model output from the "SREF" suite of guidance (27 individual members each with slightly different configuration, and thus, answers) for two different locations: Blacksburg (BCB) and Danville (DAN). For both these locations the SREF members showed a significant range of total snowfall from as late as late morning on the 21st (18-20 hours before the start of the event). Many of the forecasts were for extreme amounts of snow as shown in the figures and explained in the captions below them. By very early morning on the 22nd, about when the event was beginning, the averages had dropped slightly and there was a little less spread in solutions as well, but still some degree of uncertainty in terms of how much snow would fall before the event ended. Of course, forecasters have other models besides these, we use observational data (including special upper air soundings released twice as often as usual before and during this storm), and our experience in recognizing patterns from past events. We then collaborate with neighboring NWS forecast offices as well as our national center experts before making our final forecasts. This model output shown below is an illustration of how similar forecast systems can take the same starting data and come up with different solutions, even in an event that on the large scale was relatively easy to forecast.

There is a table of snowfall totals near the bottom of this document that includes both BCB and so you can see how these SREF snowfall forecasts compared with what finally happened.

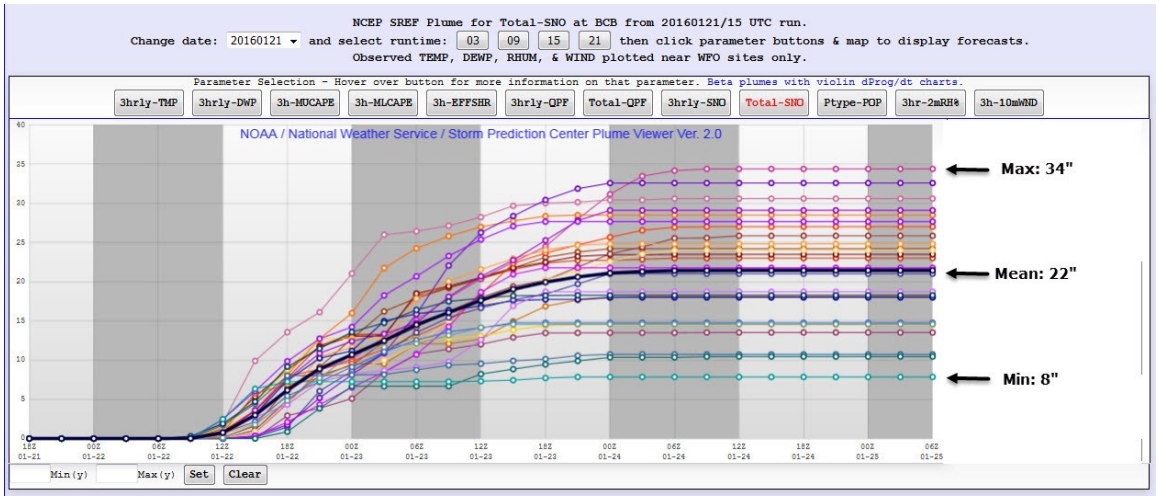


Fig. 8. SREF ensemble accumulated snow total forecasts for BCB from late morning on Jan 21. The mean forecast was 22", with a majority of members forecasting greater than that (as high as 34"!).

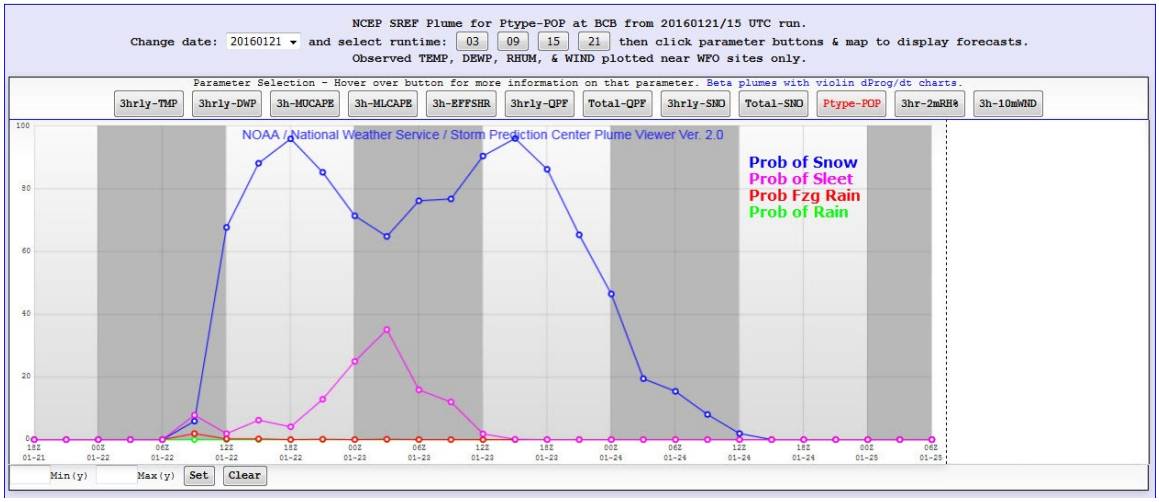


Fig. 9. SREF probabilities of precipitation types from the late morning run on Jan 21, showing snow would be the most likely precip type, with a small chance for sleet for a period Friday evening the 22nd.

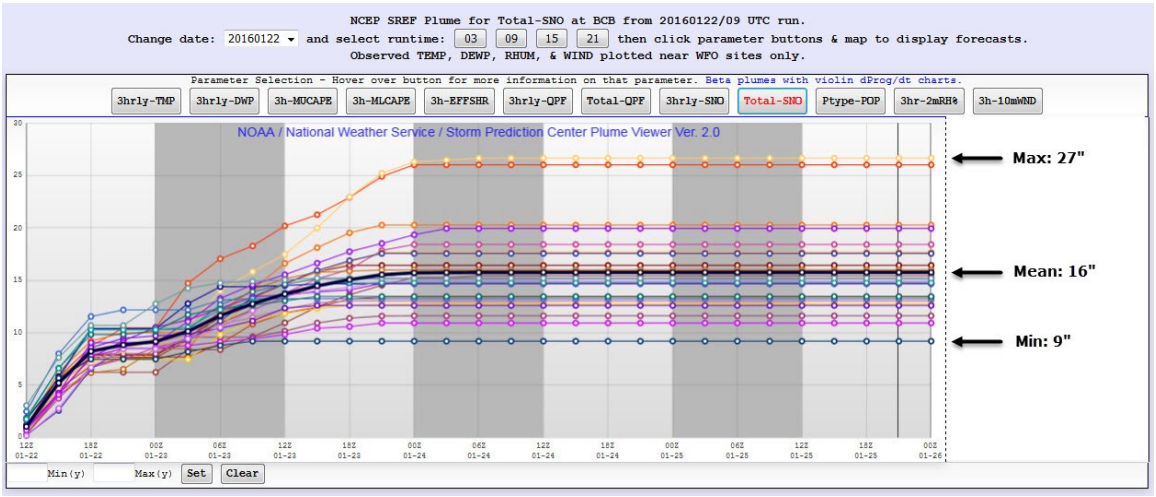


Fig. 10. SREF accumulated snow total forecasts for BCB from the early morning run Jan. 22 (about the time snow was starting), showing the mean value had lowered to 16" as well as closer "clustering" of the solutions (better confidence), but still a couple of solutions forecasting 27".

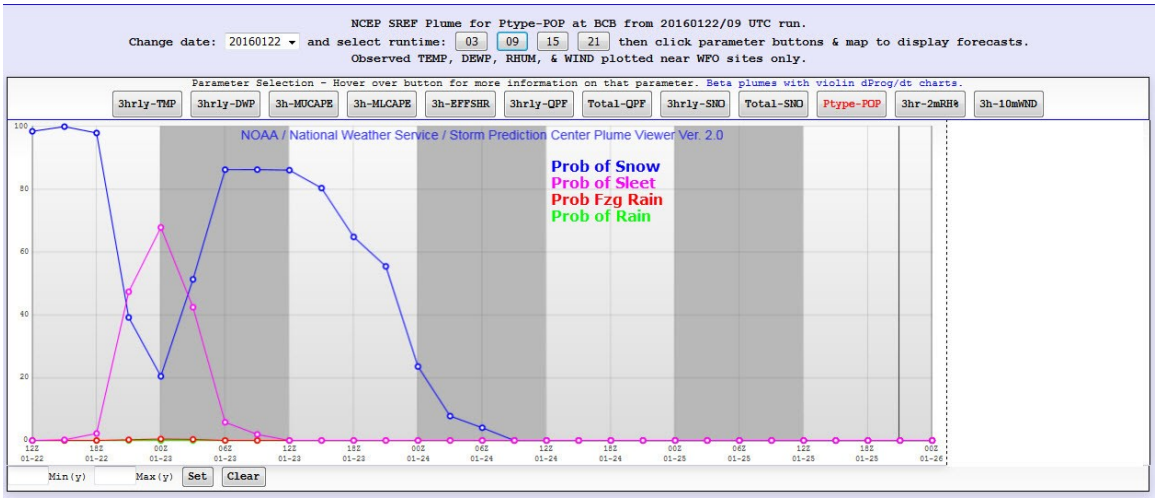


Fig. 11. SREF probabilities of precipitation types from the early morning run Jan. 22, showing now a better chance for sleet to occur for a few hours late Friday the 22nd (one reason for the lower snow accumulations in Fig. 10).

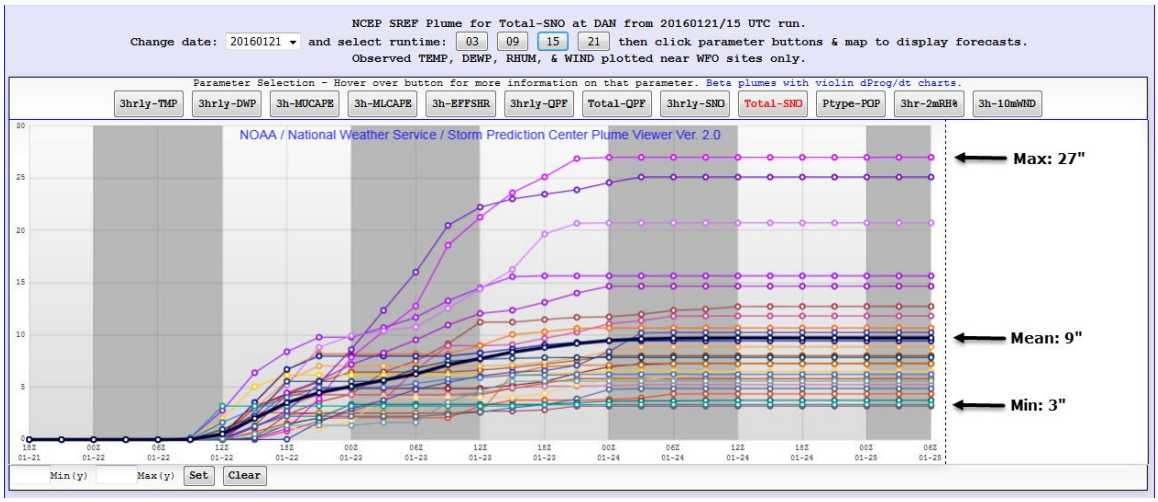


Fig. 12. SREF accumulated snow totals for DAN from the late morning run on Jan. 21, showing a wide spread of solutions but with a mean of 9" and some outlier forecasts over 25".

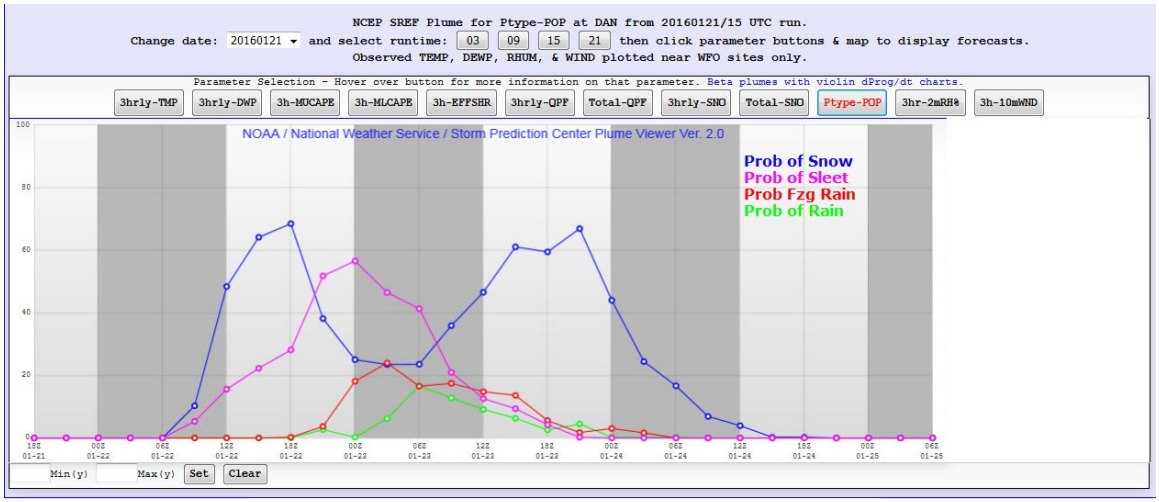


Fig. 13. SREF probabilities of precipitation type for DAN from the late morning run on Jan. 21, showing mainly snow, but a strong likelihood of sleet and perhaps even some freezing rain mixing in late on Friday the 22nd before turning back to snow.

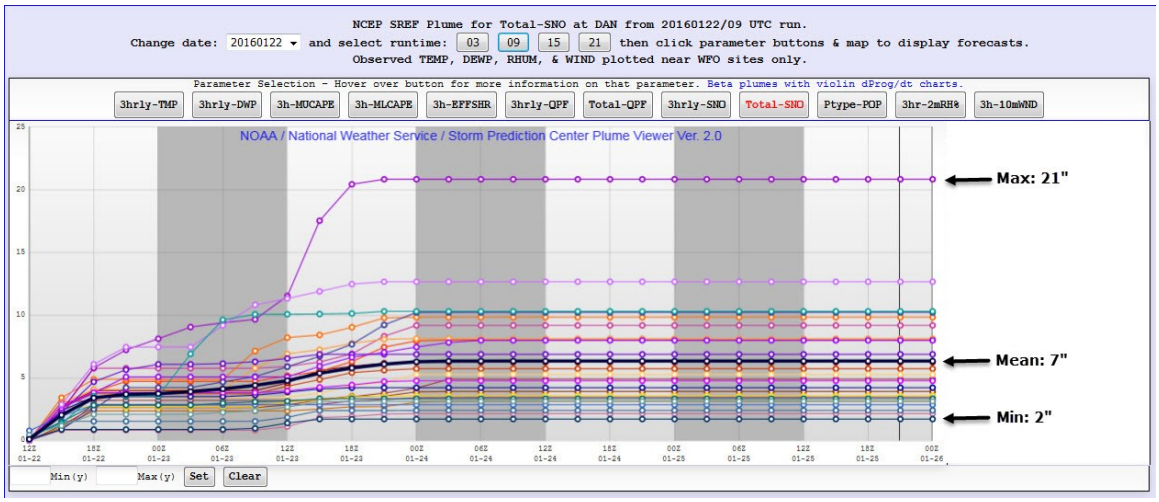


Fig. 14. SREF forecast accumulated snow totals for DAN from the early morning run on Jan. 22 (just before the snow started), showing the mean value lowering to 7" and strong clustering around than, but still with a high outlier of 21" and a minimum of 2".

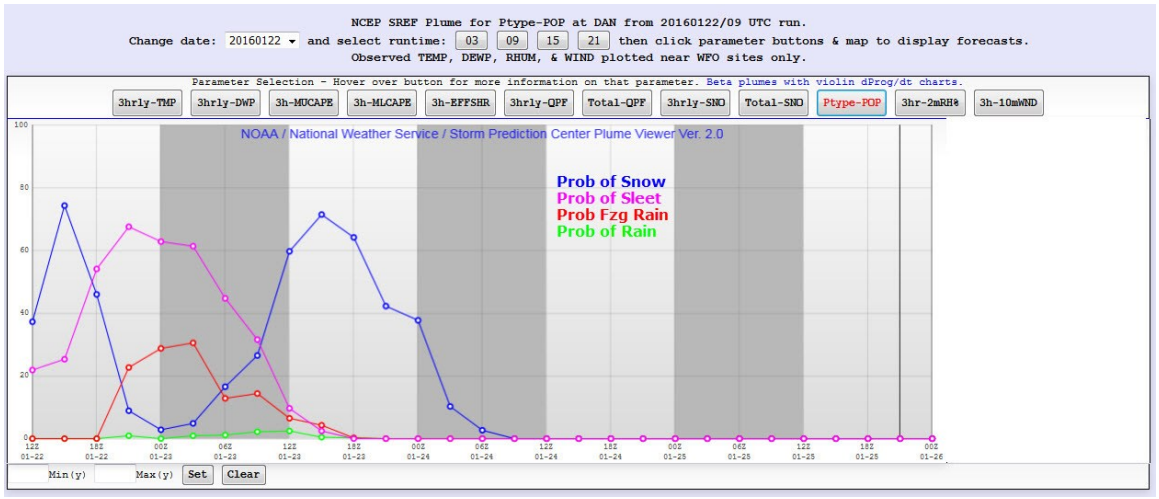


Fig. 15. SREF probabilities of precipitation type for DAN from the early morning run on Jan. 22, showing a trend toward more sleet forecast and slightly better chance for freezing rain Friday evening the 22nd.

Observed upper air soundings

As shown above, Friday evening (Jan. 22) was expected to be a critical time when precipitation would be most likely to switch from snow to sleet (or even freezing rain) for a period of time across the area. These soundings from balloon launches at Blacksburg (upper air station ID is "RNK") and the Triad Airport near Greensboro ("GSO") were from 7pm that evening. The first shows the temperature profile essentially all below freezing (0 deg C is highlighted with the blue line), but very close to that mark just a few thousand feet above the ground. Sleet was actually observed in Blacksburg around this time for a couple of hours and so there were likely brief periods where the temperature got perhaps 0.5 to 1.0 deg (C) above freezing, which caused the partial melting of ice crystals and thus sleet. This occured during some of the higher precipitation rates that moved over the area late on the 22nd, and thus probably cut down on final accumulations by a couple of inches compared to if it had all been snow.

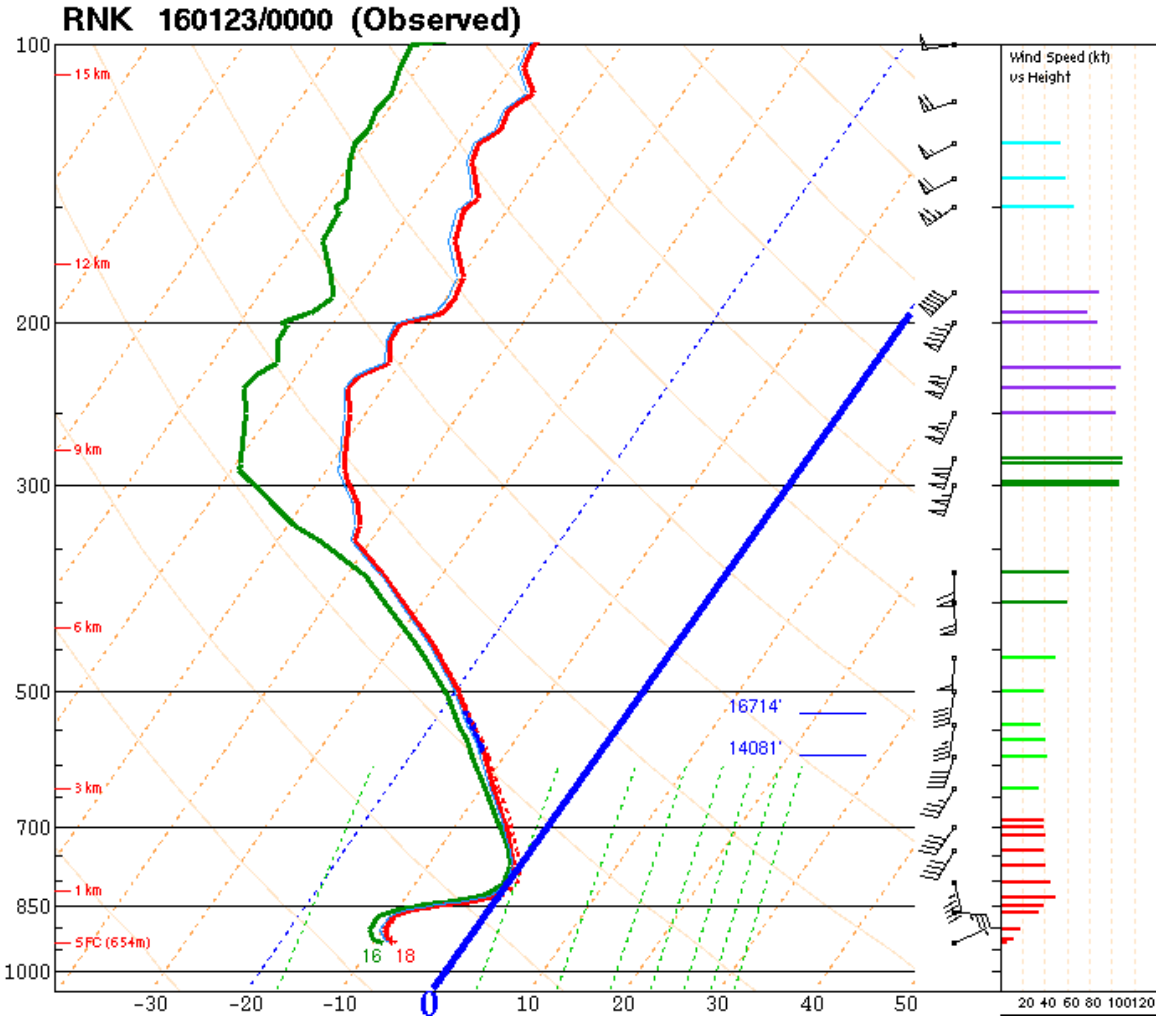


Fig. 16. Upper air sounding from Blacksburg at 7pm Friday evening (Jan. 22), showing a narrow layer that was close to and perhaps briefly was (before or after this), above freezing (blue line).

The sounding at Greensboro from the same time (7pm Jan. 22) showed a strong nose of warmer air a few thousand feet above the ground compared to at Blacksburg, suggesting mainly sleet but perhaps warm enough for even a little freezing rain. There were reports of sleet off and on across north-central NC and Southside VA during the afternoon and into the evening, as well as some light freezing rain in the Greensboro area (as well as south and east of there).

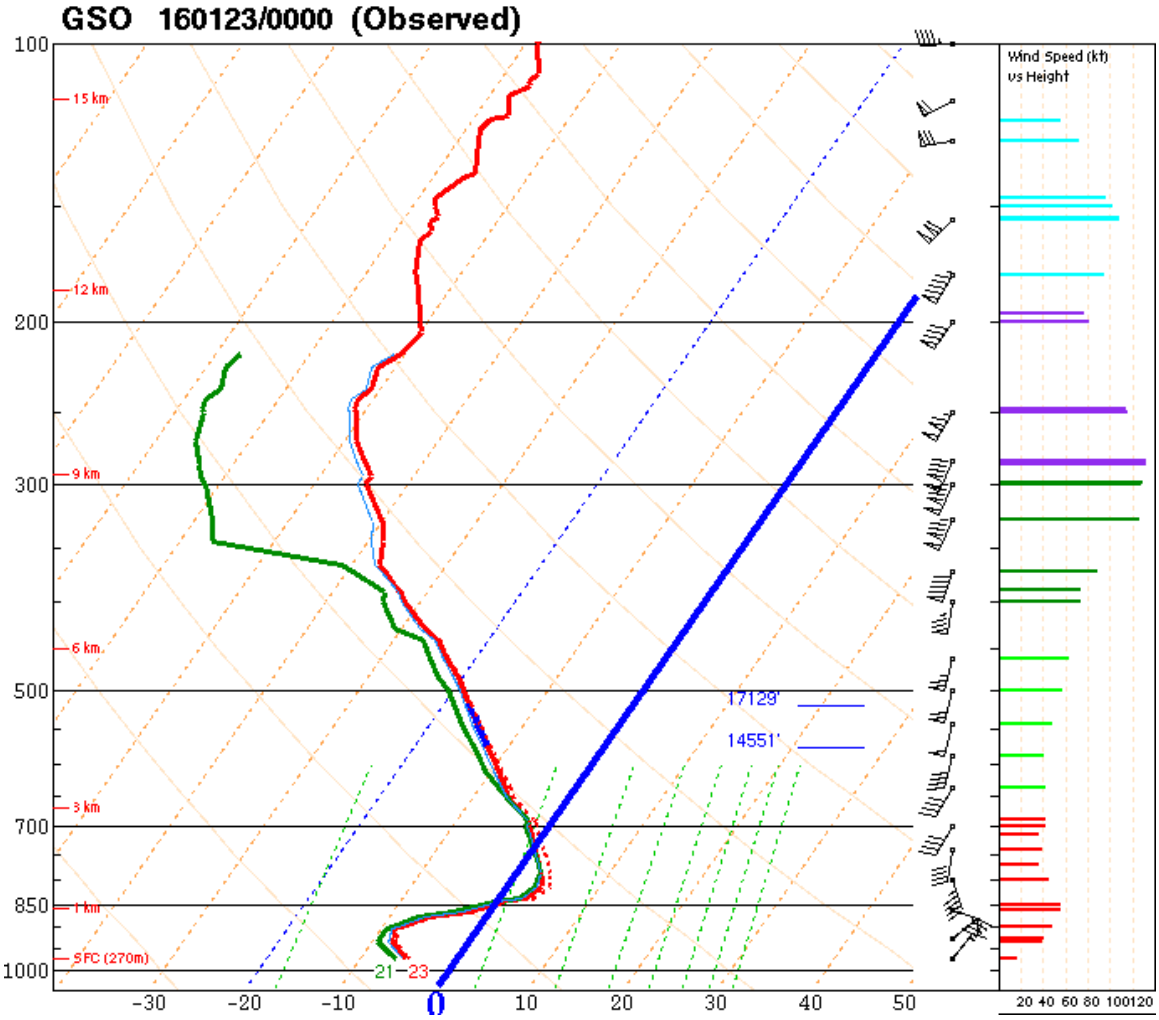


Fig. 17. Upper air sounding from Greensboro at 7pm Friday evening (Jan. 22) showing a stronger warm layer a few degrees (C) above freezing (blue line).

Forecast vs. observed snow amounts NWS Blacksburg's area

The NWS snowfall forecast issued the morning of the 21st (about when the Winter Storm Warning was issued) is shown below in Figure 18. Later in the day we actually increased these total. This was based on much of the guidance continuing to increase the maximum potential and more confidence in this classic pattern coming together, as well as the thought that most of the precipitation would fall as snow. It wasn't until just as the snow was beginning (as shown above in the SREF plume diagrams from the early morning run on the 22nd in Figs 10&11, and Figs 14&15), plus upstream observations, that the evidence was becoming more clear that a drier air intrusion and a warmer nose of air aloft would play a role after all, and thus likely hold down the totals from what was originally forecast. So, in general, the snowfall forecasts for our area ended up being a little on the high side, but for at least the western half of the region many of the final totals were within our initial range but on the lower end. The final snowfall analysis map (Fig. 19) is shown below the forecast map (Fig. 18).

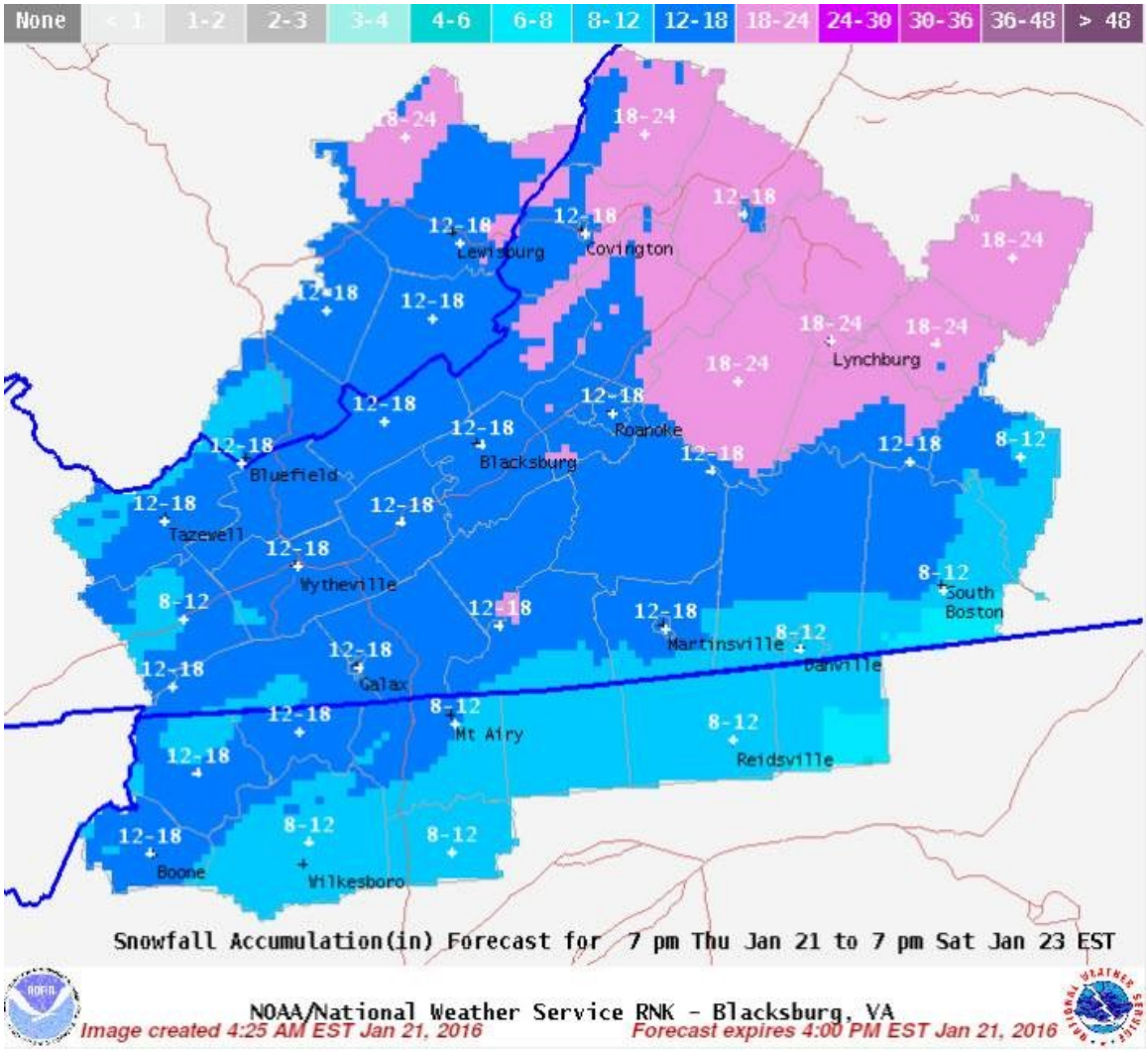


Fig. 18. NWS Snowfall forecast issued early morning on Jan 21, 2016.

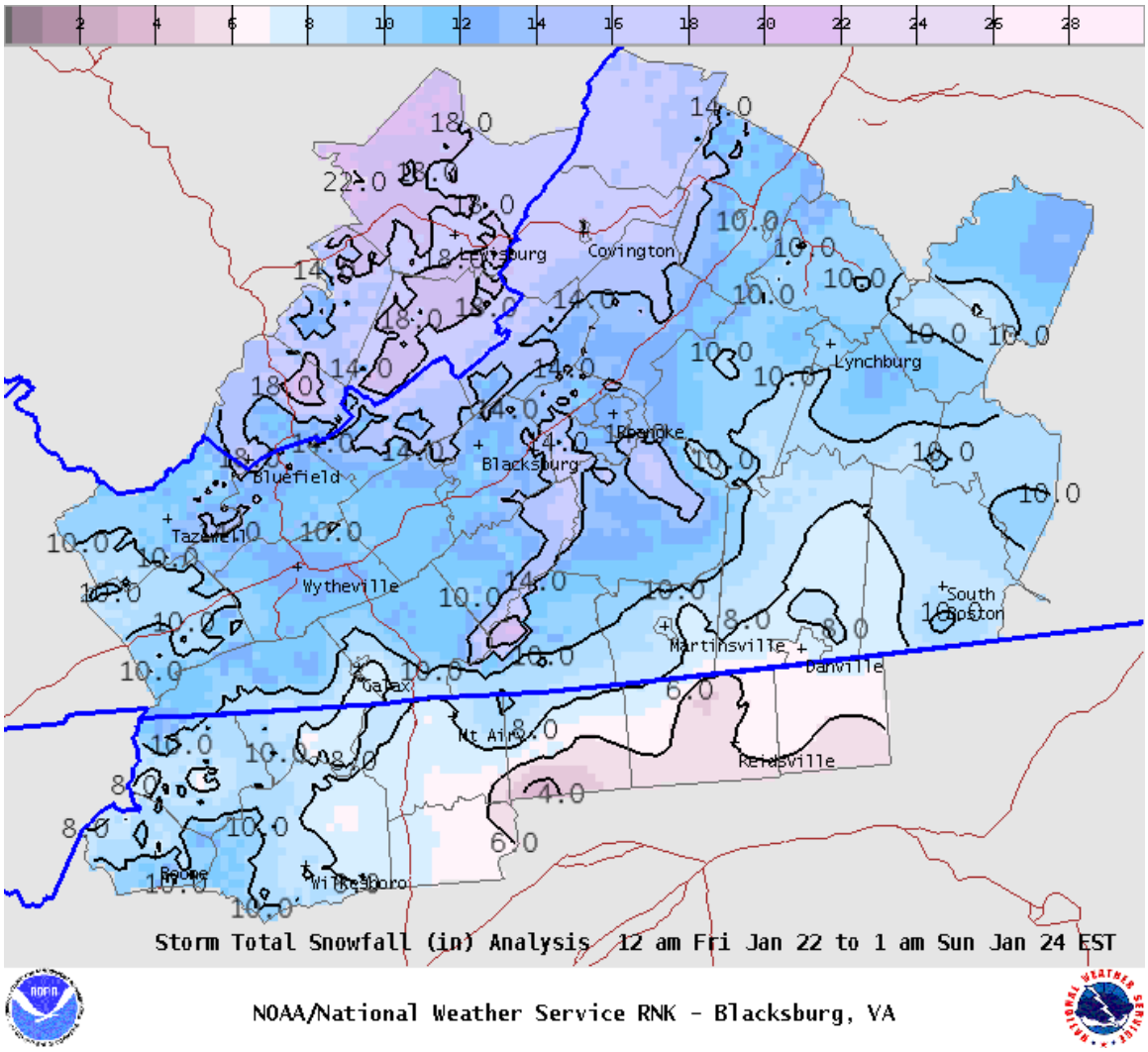


Fig. 19. Final snowfall analysis for the event beginning close to midnight early on Jan. 22, and ending late evening on the 23rd.

Summary

The official totals at our five climate stations are shown in the table below, which also indicates that with the exception of Bluefield WV, none of these made the Top 10 for storm total snow amounts. Keep in mind that accurate snowfall measurements are very difficult during windy conditions as we had with this storm. We know that all trained observers did their best to provide measurements as accurately as possible for these stations and many of the locations used to produce the map above, and we appreciate those efforts very much!

Despite amounts that were a bit lower than forecast, this was still a major winter storm with significant impacts to travel given the amounts and tendency for some drifting. There were some traffic accidents across the region, but these were

likely limited because most businesses and schools were shut down allowing most people to avoid venturing out on roadways. Power outages were limited as well since the snow amounts were a little lower and the character was a little drier than originally thought (combined with the mix of sleet which does not tend to stick on trees and power lines but falls straight to the ground), and winds that were not quite as strong either.

Jan 22-23, 2016 Snow Totals at Official Climate Sites

(None made the Top 10 for any station except for Bluefield, WV)

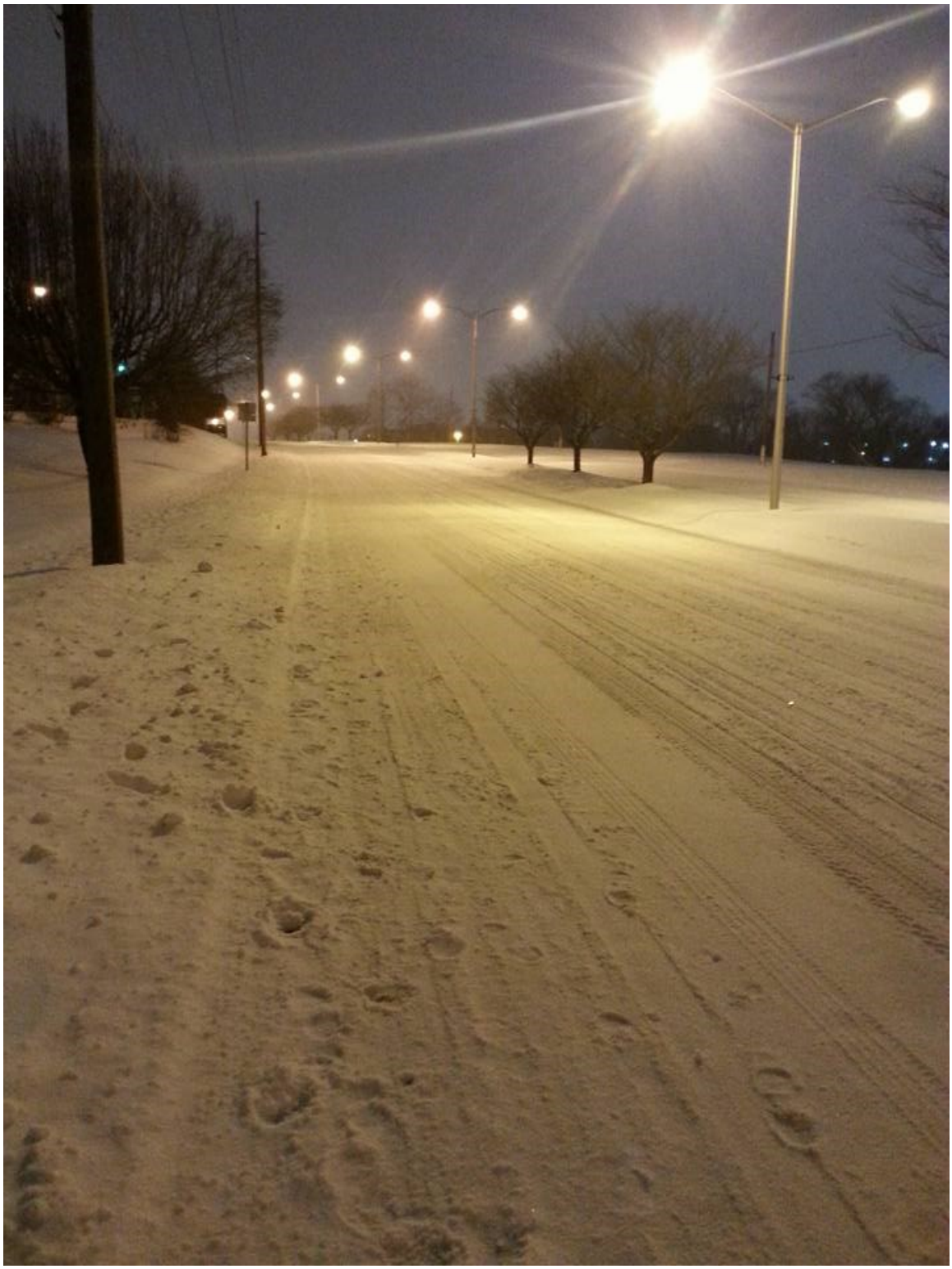
KROA (Roanoke, VA)	KBCB (Blacksburg, VA)	KLYH (Lynchburg, VA)	KDAN (Danville, VA)	KBLF (Bluefield, WV)
13.0"	13.0"	10.1"	7.8"	14.0" (8th)

Largest amount in our forecast area from an official reporting station was 20.0" from the observer near Rupert, WV

We conclude this summary with a series of photos taken from around the region which give a sense of the impacts from this first major snowstorm of the 2015-2016 season. We appreciate all those who sent in photos via social media and email!

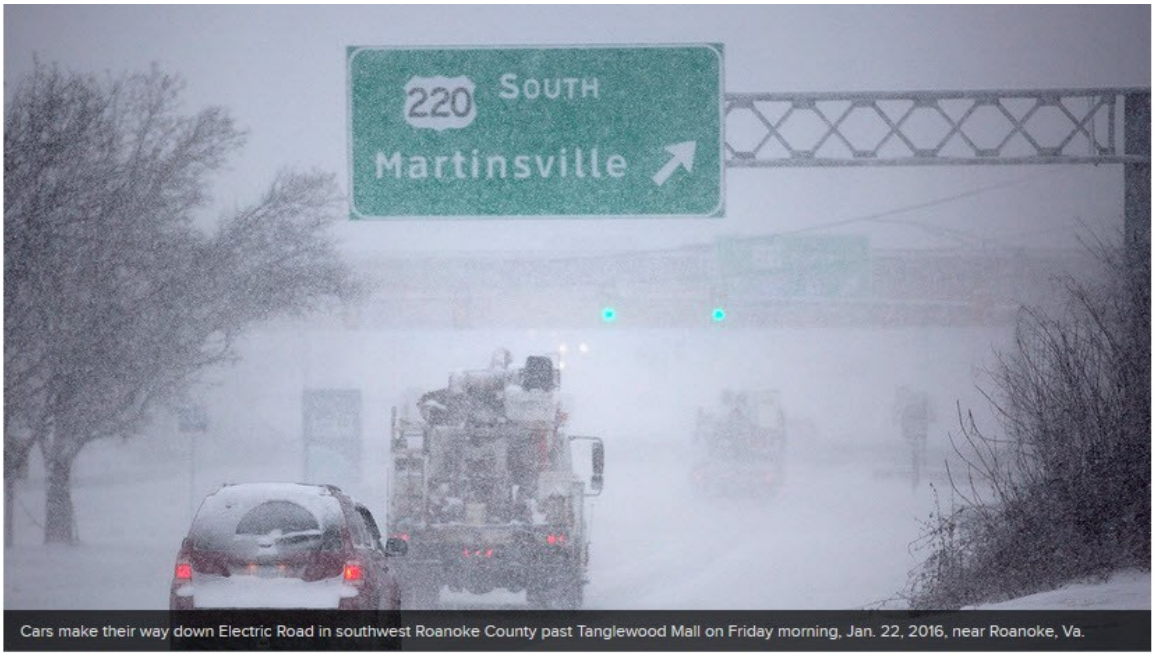
(Christiansburg, VA, by Patricia Douglass)]

Virginia Tech campus (by Peter Corrigan)



Memorial Drive in Danville, VA (from Angela May Guinn via Social Media)

Downtown Roanoke, VA (Roanoke Times)



Cars make their way down Electric Road in southwest Roanoke County past Tanglewood Mall on Friday morning, Jan. 22, 2016, near Roanoke, Va.

IMAGE: ERICA YOON/THE ROANOKE TIMES VIA AP

Roanoke VA near Tanglewood Mall (Roanoke Times)

Highway 421 East of Wilkesboro, NC (from Helena Jolanta via Social Media).

Stokes County, NC (from Monty Stevens).