Central U.S. Snowstorm and Southeast Severe Weather Outbreak
April 14-16, 2011
By: Dave Hamrick, HPC Meteorologist

Overview: A large and multi-faceted low pressure system evolved over the Central Plains on April 14th and combined with very cold surface temperatures to create a late-season snowstorm. Widespread moderate to heavy snow developed in the deformation zone, with some amounts in excess of 10 inches reported. Localized blizzard conditions developed over South Dakota, north-central Nebraska, and south-central North Dakota, where moisture converged along a trough axis. This resulted in the closures of sections of Interstates 80 and 90, leaving many travelers stranded (Fig. 1a). Given surface temperatures near freezing, this was a relatively wet snow when compared to the drier snow this region typically receives in the winter. In the warmer environment near and to the south of the low, rain was the primary precipitation type.

This same system also generated a widespread severe weather outbreak with numerous reports of tornadoes, high winds, and hail in the warm sector east of the cold front and south of the warm front. A steady influx of 65+ degree surface dewpoints, warm boundary layer temperatures, and deep layered directional and speed shear all combined to create an environment favorable for severe thunderstorms and tornadoes. On April 16th, the severe weather had shifted to the East Coast, with North Carolina having one of its worst tornado outbreaks in recorded history (Fig. 1b). A total of 162 confirmed tornadoes occurred over a three day period for the entire event, including 30 EF-2 tornadoes and 14 EF-3 tornadoes, and hundreds of severe hail and wind events were reported (Fig. 2).

Fig. 1a. A traffic cam picture of a snow-covered Interstate 90 near Mitchell, SD, on April 15th. Photo courtesy of the South Dakota Department Of Transportation.

Fig. 1b. A rain-wrapped tornado near downtown Raleigh, NC, on April 16th. Photo courtesy of WRAL-TV.

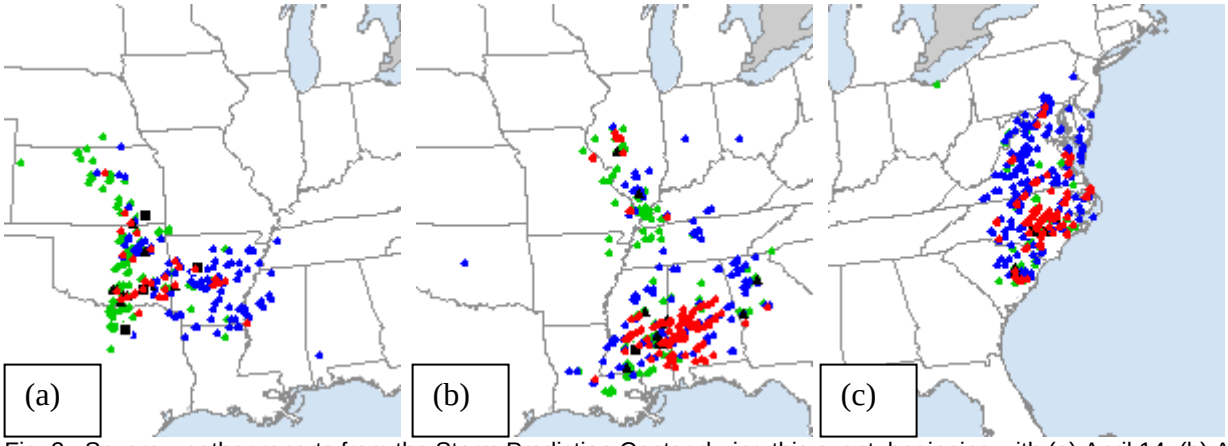


Fig. 2. Severe weather reports from the Storm Prediction Center during this event, beginning with (a) April 14, (b) April 15, and (c) April 16. The red dots are tornado reports, the blue dots are high wind reports, and the green dots are hail reports. It is important to note that some tornado tracks received multiple reports.

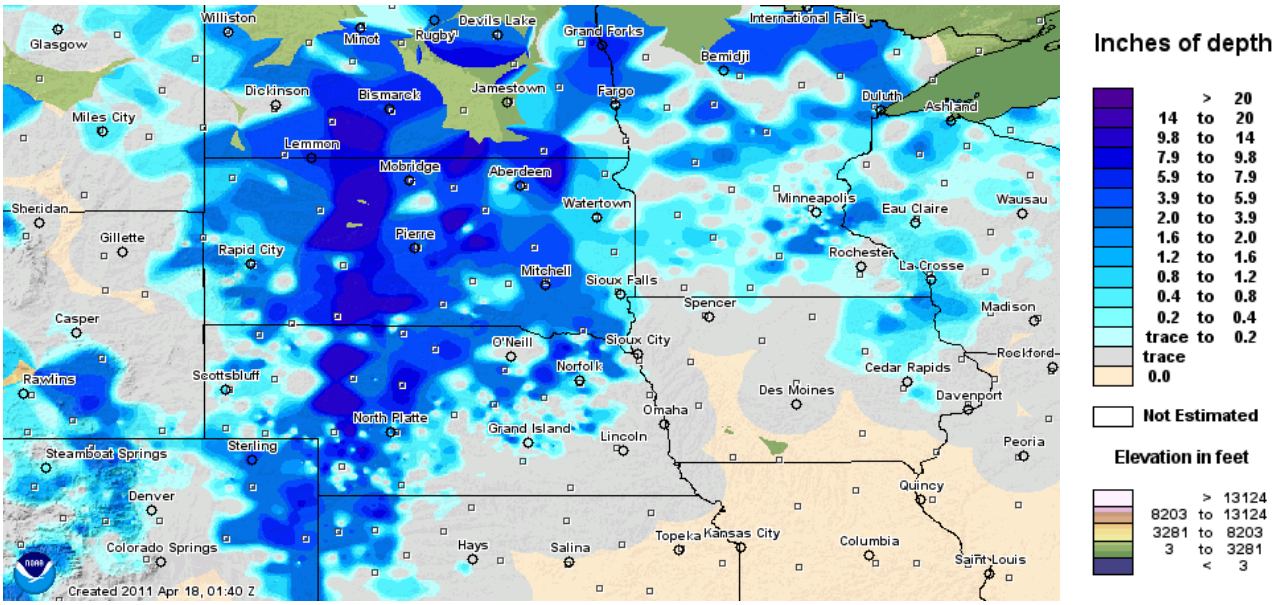


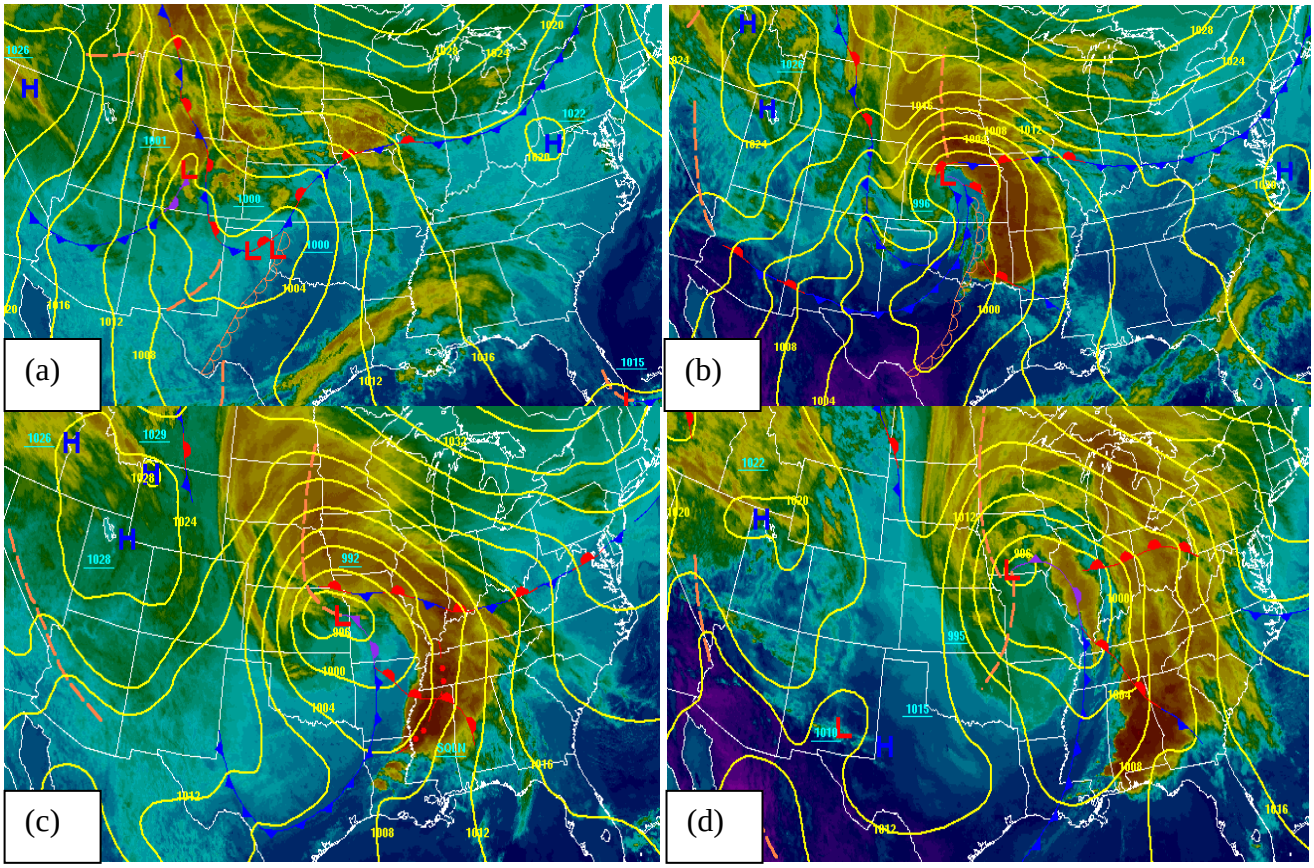
Fig. 3. Map of observed snowfall from the National Operational Hydrologic Remote Sensing Center.

Synoptic Environment: A late season snowstorm developed over the Northern Plains and into parts of the upper Midwest, bringing blizzard conditions and snow amounts on the order of 10 inches (Fig. 3). The storm was associated with a vigorous shortwave. The surface analysis shows the storm system moved east out of the northern Rockies and emerged over the Central Plains as a 992 mb cyclone by 12 UTC on the 15th (Fig. 4). Around the same time, a deep and negatively tilted upper trough axis was clearly evident in the 250-mb flow (Fig. 5a) over the central U.S., with a jet streak over eastern New Mexico and northern Texas. A strong, closed low was observed at 500mb and levels below (Fig. 5a-c). At each level an inverted trough was present in the height and wind fields, which served as a local maximum of vorticity. This inverted trough was reflected at the surface, extending from the center of the low northward into the Dakotas by 12 UTC 15 April (Fig. 4c). Upper-level warm

air and vorticity advection, as well as surface convergence along this trough axis, was likely responsible for the axis of enhanced snowfall that was observed.

The vigorous shortwave continued moving into Arkansas and parts of the Deep South by April 15th. The situation was favorable for severe weather with strong mid and upper level winds, steep lapse rates and a southerly low level jet from the Gulf of Mexico, advecting 65 to 75 degree surface dewpoints into the Southern Plains and Deep South.

The Storm Prediction Center had moderate risks for severe weather for both April 14th and April 15th over parts of the Southern Plains and Deep South, and a high risk for severe weather on April 16th over eastern North Carolina and adjacent areas of Southeast Virginia and northeast South Carolina. Over the course of the entire event, SPC issued 17 tornado watches (two of which were PDS) and two severe thunderstorm watches.



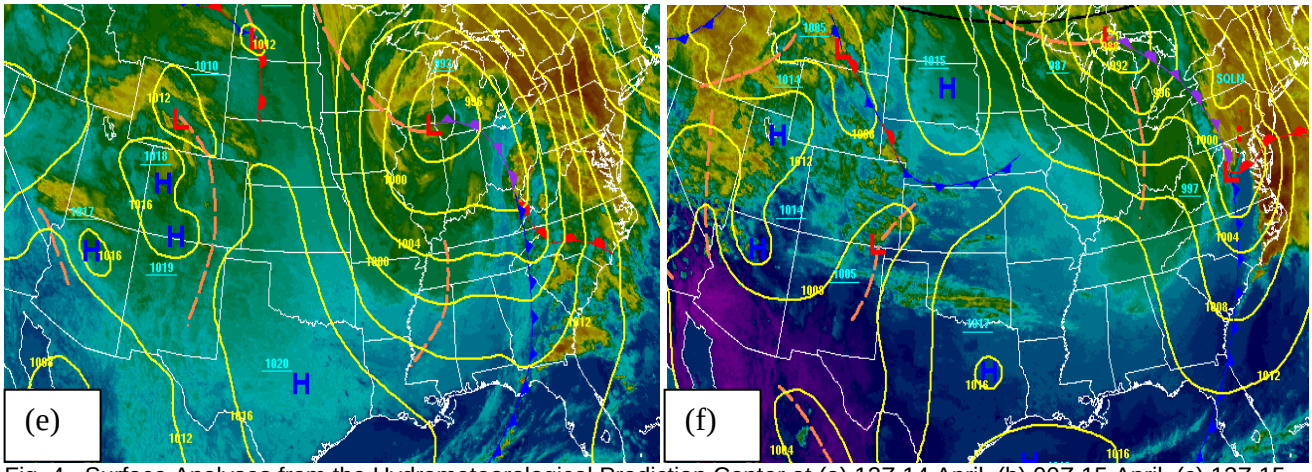


Fig. 4. Surface Analyses from the Hydrometeorological Prediction Center at (a) 12Z 14 April, (b) 00Z 15 April, (c) 12Z 15 April, (d) 00Z 16 April, (e) 12Z 16 April, and (f) 00Z 17 April, along with infrared satellite imagery.

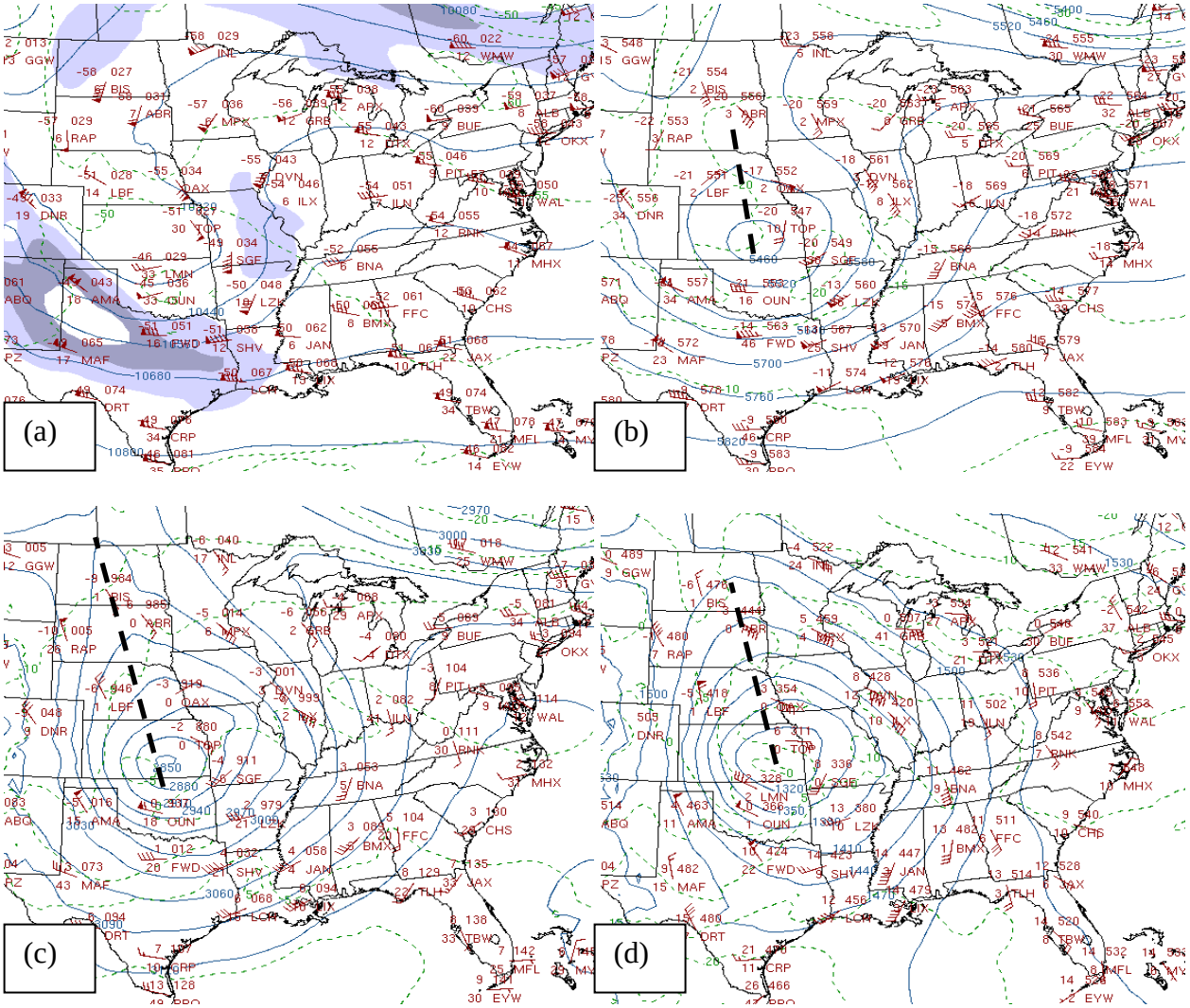


Fig. 5. These graphics show the overall structure of the troposphere at the height of the event at 12Z on April 15th. Analyses shown are (a) 250mb, (b) 500mb, (c) 700mb, and (d) 850mb. Images courtesy of the University of Wyoming. The thick, dashed lines indicate the position of the inverted trough at the given level.

Mesoscale Processes: A visible satellite image of the large-scale cloud pattern (Fig. 6) associated with this system clearly shows a thick band of cumulonimbus clouds over eastern Kansas and extending southward into southeast Oklahoma (Fig. 6). Over western Oklahoma and central Kansas, a pronounced dry slot wrapped into the low and gave the system a well-defined comma-head appearance. The heavy snowfall was observed within the area of stratiform precipitation on the north side of the low. Farther to the south over New Mexico and western Texas, the thin and milky-looking clouds are likely wind-blown dust and smoke from wildfires behind the dryline. East of the dryline, cumulus cloud streets are evident in the warm and humid sector with deep southerly flow.

The remainder of the focus here will be on the severe thunderstorms that occurred within the warm sector of this system. The highly sheared environment ahead of the cold front allowed for the development of numerous discrete supercell thunderstorms, and many of these produced tornadoes. National Weather Service Doppler radars frequently showed bounded weak echo regions (BWERs) within the updraft region of these storms, along with well-formed hook echoes. An example of such a storm can be found in Fig. 7. Southeasterly winds at the surface veered to the southwest at the 850mb level, generating high helicity and thus tornado potential. A secondary area of severe weather reports over the middle Mississippi River Valley, especially southern Illinois, was along the leading edge of the occluded front and away from the higher moisture profiles to the south, but enough shear and lift was present to develop severe thunderstorms.

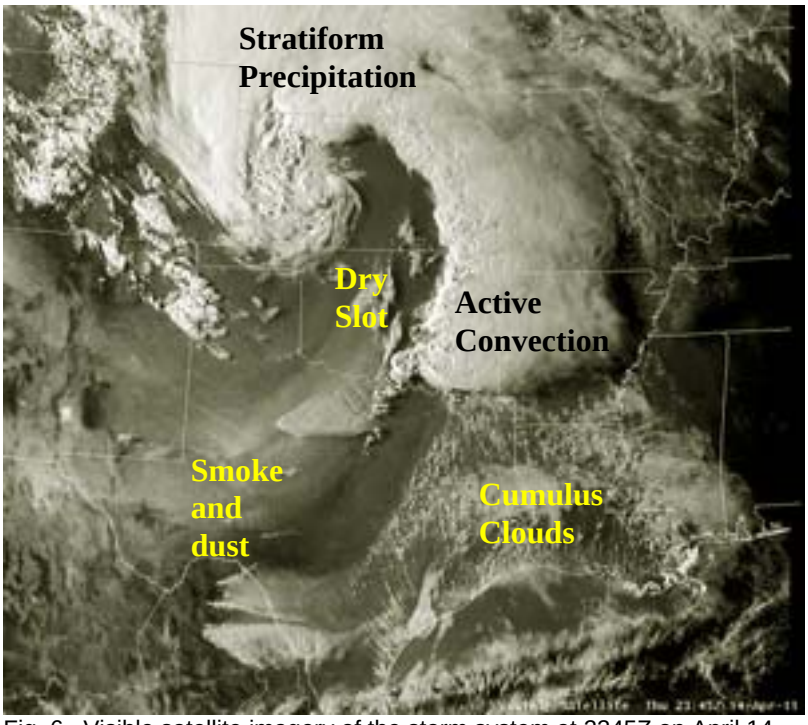


Fig. 6. Visible satellite imagery of the storm system at 2345Z on April 14.

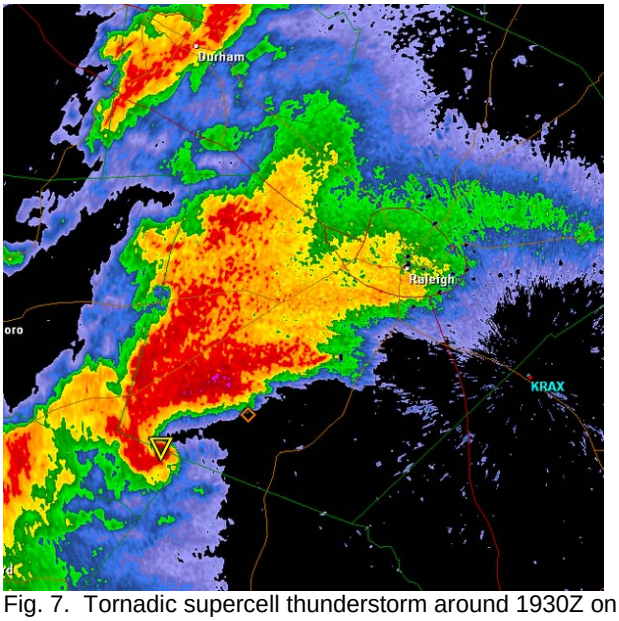


Fig. 7. Tornadic supercell thunderstorm around 1930Z on April 15th shortly after it caused damage in Sanford, NC, and moving towards Raleigh, NC. The tornadic vortex signature is clearly evident by the distinct hook echo on the southwest edge of the storm near the yellow triangle. Image from Raleigh NWS Doppler radar.

The contrast of the air masses can be shown through soundings. The 12Z sounding on April 15th from Jackson, MS (Fig. 8a) had a high level of CAPE and boundary layer moisture in the presence of strong veering winds in the lowest 200 mb of the troposphere. The Greensboro sounding the subsequent day (Fig. 8b) had a thick layer of low-level moisture in the presence of a very strong low level jet, with very dry mid-level air above 600mb. In stark contrast, on the cold side of the system, the Aberdeen sounding (Fig. 8c) shows a deep layer of saturation through the lower and mid-levels, including in the dendritic growth region (-12°C to -18°C). Ascent occurring at these temperatures can create efficient snowfall. Images courtesy of the University of Wyoming.

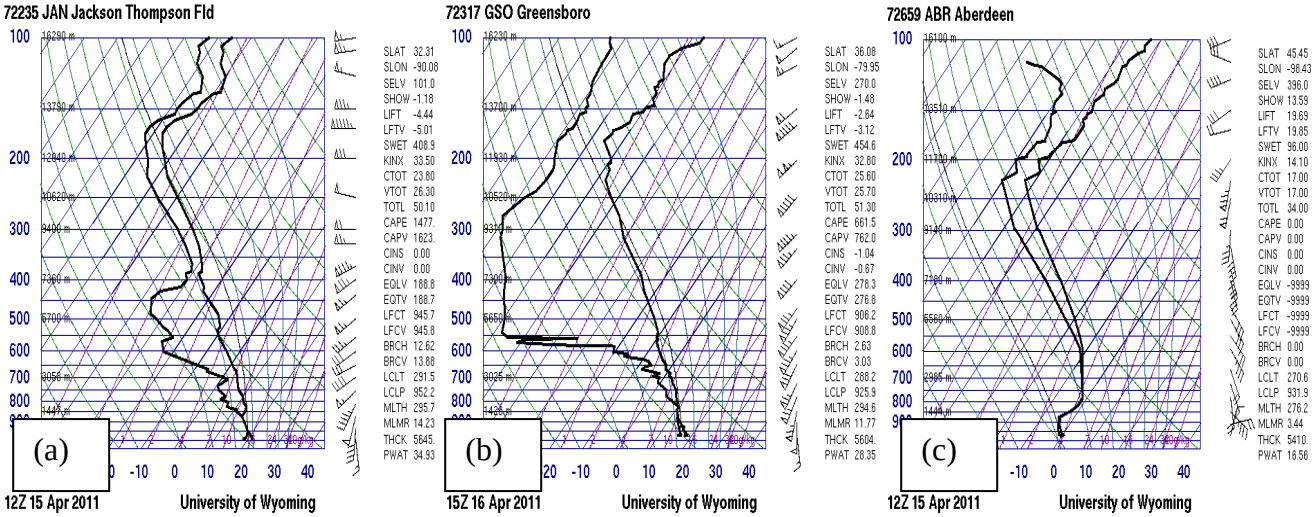


Fig. 8. The sounding in panel (a) is the pre-storm environment for the severe weather outbreak in Jackson, MS, panel (b) is the pre-storm environment in central North Carolina at Greensboro, and panel (c) is around the time of heaviest snow for Aberdeen, SD.

Conclusion: This snow event was one of several winter storms to affect the Northern Plains during the spring of 2011. The event was unusual for how late in the season it occurred. Roadways and air travel were severely affected by this late season snow event, and it only added more moisture to a ground that was already saturated. This event is among one of many that contributed to the widespread flooding issues that were observed in the Missouri River Basin during the subsequent summer of 2011.

The severe weather event that unfolded across the Southern Plains and into the Southeast from this same storm system was a major outbreak. A total of 38 people were killed from the tornadoes and 5 others were killed by damaging straight-line winds. This was the greatest number of weather fatalities from a severe weather outbreak since the Super Tuesday outbreak in February 2008 weather on April 16th, but was quickly overshadowed by the southeast U.S. tornado outbreak later in the month (Tuscaloosa, AL.) on April 27th.