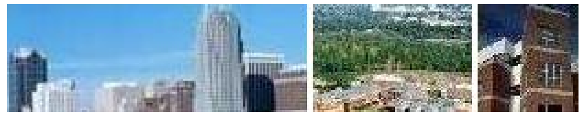
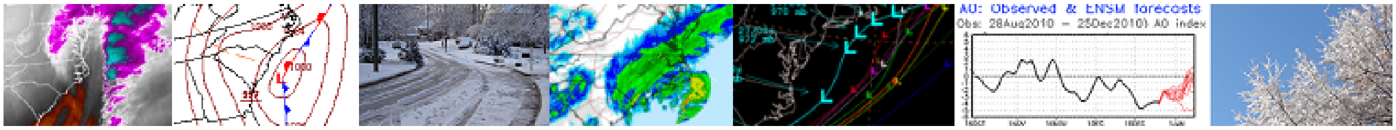
Event Summary

National Weather Service, Raleigh NC



December 25-26, 2010 Winter Storm

Note that this is a PDF version of the event summary and that some links, media or resources may not be avaiable in this format.

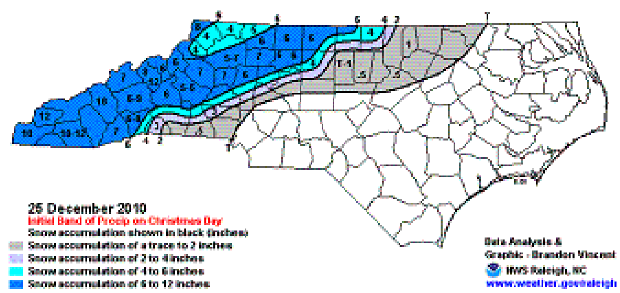


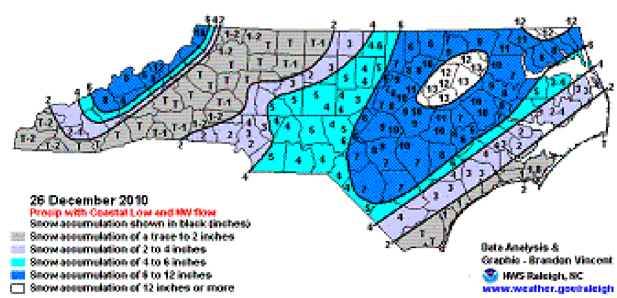
Event Headlines

...This winter storm produced a large swath of snow that extended across the Midwest into the Ohio Valley, Tennessee Valley, the Southeast, Mid Atlantic and eventually the Northeast. A total of 25 states reported accumulations of 6 inches of more...
...Winter Storm Watches were issued for 23 of the 31 counties in central North Carolina with all of the watches verifying and 8 missed events. The average lead time for all of the watches was just over 31 hours. Winter Storm Warnings were issued for all 31 counties with all counties verifying and no false alarms or missed events. The average lead time for all of the Winter Storm Warnings was just over 24 hours...
...The event generally followed a "Miller A" surface pattern in which a single well developed low pressure system developed in the Gulf of Mexico and tracked northeast across Florida before moving up the U.S. east coast while rapidly deepening. "Miller A" events typically result in a simpler precipitation pattern that includes corridors of snow and rain with a narrow transition zone in between. This results in a well defined rain-snow line with little or no icing in the narrow transition zone...
...This winter storm will be remembered for the difficulty the model guidance had in predicting the storm intensity and location in the 60 to 36 hour time frame. The difficulty was centered around whether the northern and southern jet streams would phase, which would dictate whether the storm would be weak and moved out to sea or whether the storm would significantly intensify and move up the East Coast...

Event Overview

The winter storm across central North Carolina is best described by two different mechanisms. The first part of the event produced between 3 and 7 inches of snow across the western and northern potions of the central North Carolina Piedmont during the afternoon and evening of December 25. The second part of the event generally produced between 4 and 12 inches of snow across the eastern Piedmont, the Sandhills and Coastal Plain with the greatest amounts of around a foot falling across the northern coastal plain. This snow was produced by a costal low that developed and then rapidly intensified. As the storm intensified, the rain or the mixed snow and rain changed over to all snow and brought accumulating snow to the eastern two thirds of the state.





The winter storm can be traced back to two short wave troughs that were moving across the western U.S. on 12/23. One vortex was embedded in the southern branch of the jet stream and located over the Desert Southwest region at 12 UTC on 12/23. The other shortwave trough was located in the northern branch of the jet stream and located across the northern U.S. Rockies. By 12 UTC on 12/24, the two systems were easy to identify in the upper air analysis and the water vapor imagery. The southern stream vortex was about to move into Texas and the northern stream trough was moving east across the Dakotas.

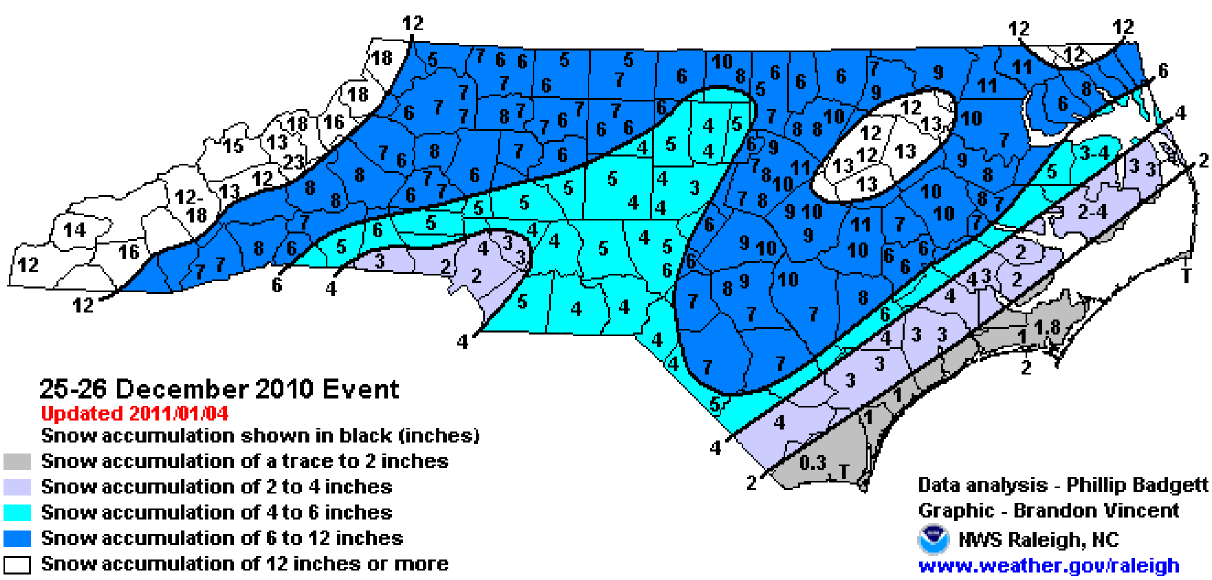
By 12 UTC on 12/25, both short wave troughs were crossing the Mississippi River and beginning to phase together. At the surface, a weak area of low pressure was located over the northern Gulf of Mexico, near the mouth of the Mississippi River. A cold and strong high pressure system (~1039 MB) was located over the northern Plains and the southern Canadian Prairie region. During the morning and early afternoon hours, a narrow band of snow developed that extended southwest to northeast near and just east of the southern Appalachians into the Foothills and western Piedmont of North Carolina. This area of precipitation appeared to be forced by lower to mid level frontogenesis along with divergence aloft associated with the intensifying northern stream jet. This snow spread into the Northwest Piedmont and Triad region during the late morning hours. With temperatures falling to around freezing, the snow accumulated to between 1 and 4 inches during the afternoon. The snow shifted east slowly and continued well into the evening with accumulations of between 3 and 7 inches common across the northwest and northern Piedmont region by nightfall. The greatest accumulations fell across the northern tier from northern Davidson County across Forsyth County, and Guilford County, and into Person County.

The area of snow that moved across the northwest and northern Piedmont during the afternoon, gradually dissipated just after 00 UTC on 12/26. At the same time, areas of light rain fell across the southern and eastern Piedmont, the Sandhills and Coastal Plain. The boundary layer was warm to the south and east of the northern Piedmont with surface temperatures in the mid to upper 30s. Even though temperatures were much colder at 850 hPa, the warmer temperatures near the surface were sufficient to melt the falling snow and produce rain as the primary precipitation type. By 00 UTC, the northern and southern jet streams had phased with a large eastern U.S. trough located over the Tennessee and Mississippi Valleys. A surface low was developing across the northeastern Gulf of Mexico with a surface pressure near 1004 MB. As the surface low intensified, reaching 1001 MB by 06 UTC, low level frontogenesis greatly increased and a large area of precipitation developed, became heavier, and spread north into southern and eastern North Carolina toward 06 UTC. This heavier precipitation which produced diabatic cooling from evaporation and then cooling from melting snow combined with a some slight cool advection, changed the rain to snow across nearly all of central North Carolina by around 06 UTC.

During the overnight hours into the morning hours on 12/26, the snow accumulated quickly with widespread light to moderate snow observed across the eastern Piedmont, the Sandhills, and the Coastal Plain. By 12 UTC, the surface low was located just southeast of Newport NC and had intensified to 992 MB. The pressure with this storm system dropped to 986 MB by 18 UTC and then 976 MB by 00 UTC on 12/27. Accumulating snow continued to fall during the morning through around midday in the Raleigh and Fayetteville areas and through the mid afternoon hours in the northern and central Coastal Plain.

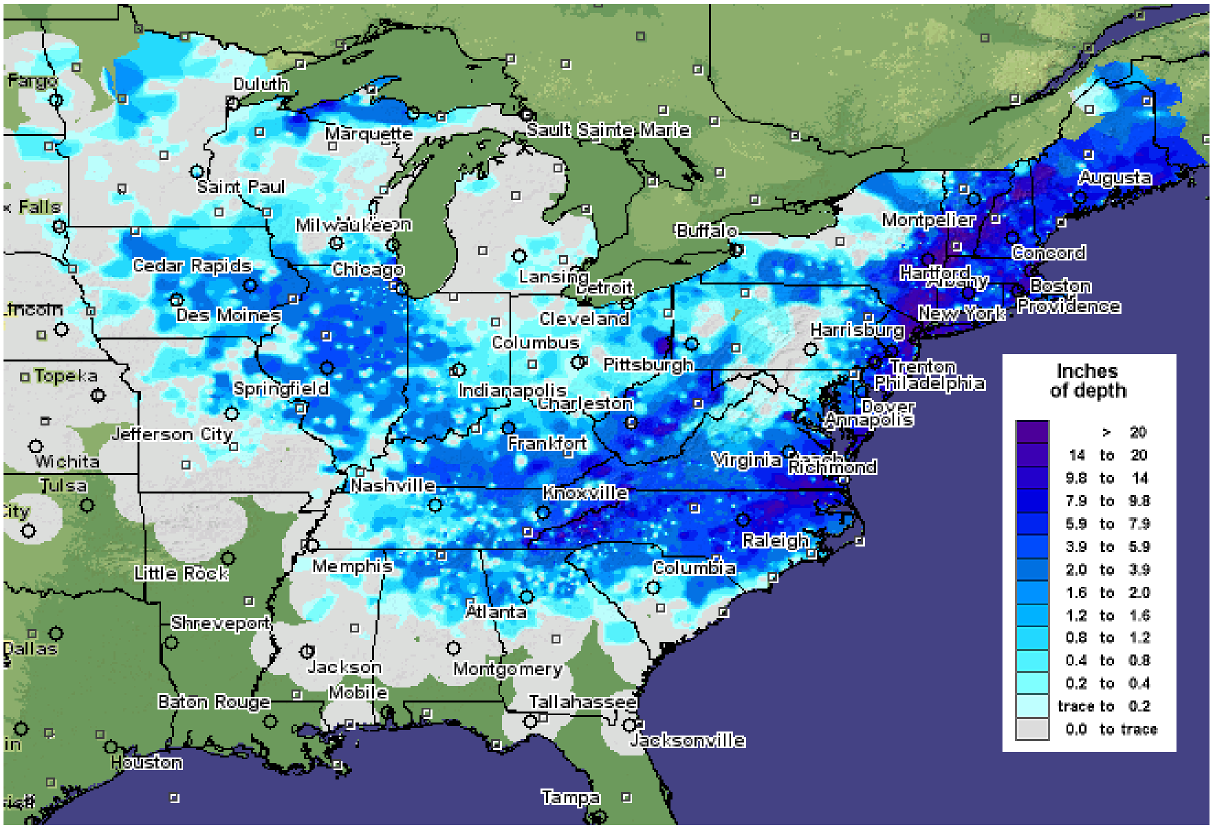
Even as the coastal low pressure area moved away from central North Carolina, the mid-upper low and associated dynamic forcing moved across the southern Appalachians into the Mid-Atlantic coast on Sunday afternoon and evening. The forcing for ascent with this feature reinvigorated the lingering light snow and flurries that had persisted in the wake of the coastal storm. Small snow grains grew to nickel to quarter-sized dendrites during the late afternoon and evening hours, as the mid levels cooled and moisture grew deeper in the minus 10 to minus 15 C layer (between 8-14 kft). This resulted in an additional inch or so of accumulation across the North Carolina Coastal Plain.

Snow Accumulation Map



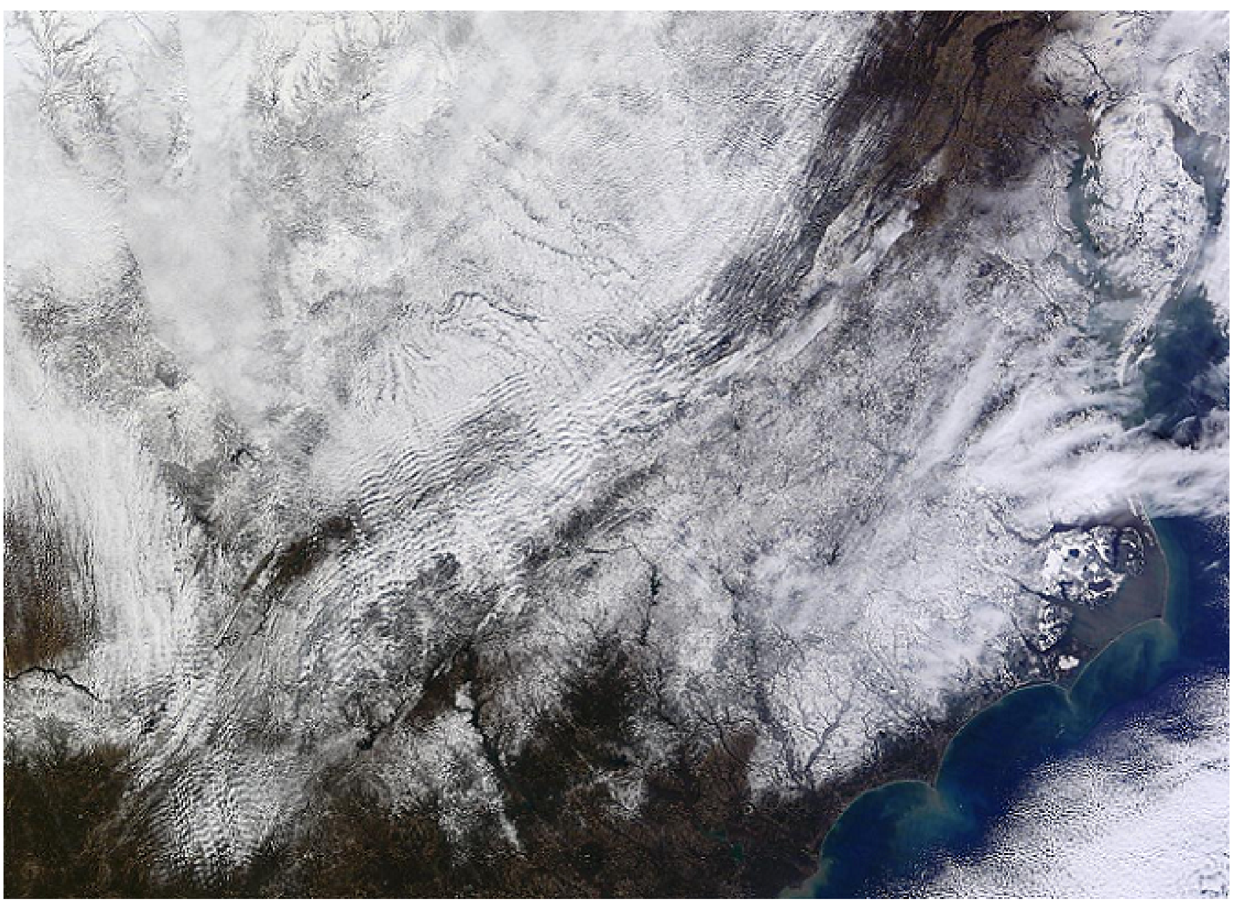
Regional Snow Accumulation Estimate

Total Observed Snowfall (Interpolated) during 72h preceding 2010 December 27, 18:00 Z

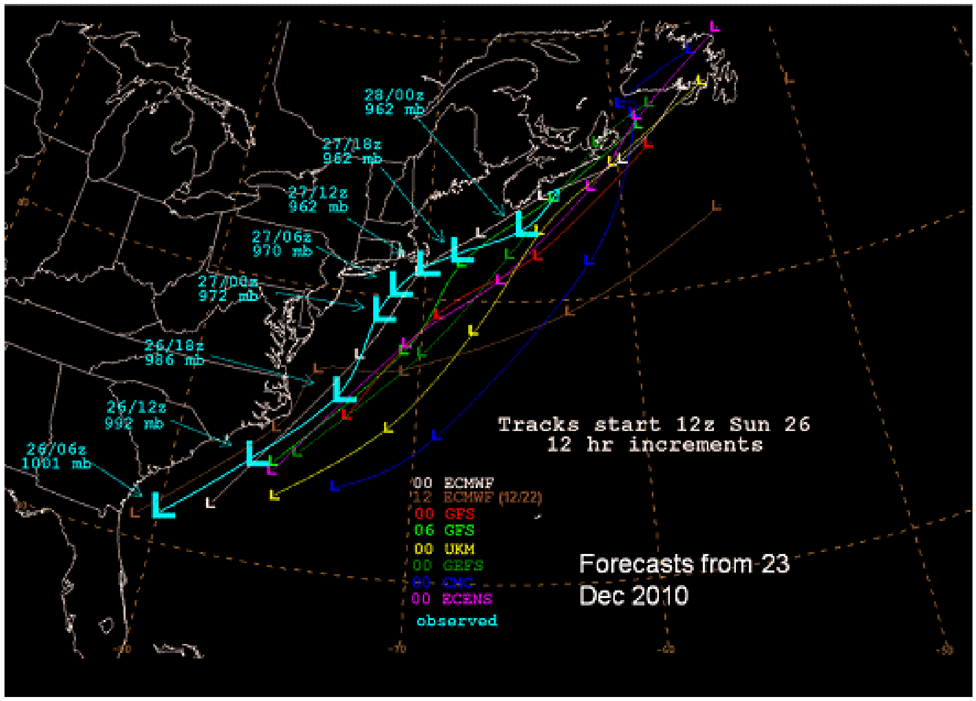


Adapted by RAH from www.nohrsc.nws.gov

MODIS Terra Satellite Image Showing Snow Cover from 2010/12/27



Forecast Challenges



This winter storm provided a significant amount of difficulty for forecasters as the model guidance shifted the storm eastward and weakened it during the 00 UTC 12/24 and 12 UTC 12/24 runs. The difficultly was centered around whether the northern and southern jet streams would phase which would dictate whether the storm was weak and moved out to sea or whether the storm significantly intensified and moved up the East Coast. The change in model guidance was frustrating for forecasters and made communicating and explaining the potential threat to our users more difficult.

A little more than a week before the storm arrived, the extended range guidance from the GFS and the ECMWF indicated the surface low would be weak and move across the Ohio Valley and Mid Atlantic. By around day 6, the ECMWF was the first set of available guidance to shift the surface low south and east and produce rapid intensification off the Southeast coast. The GFS gradually shifted the surface low southward during the day 3-5 period and also indicated rapid intensification off the Mid Atlantic coast. The GFS and ECMWF guidance on 12/23 was in fairly good agreement with a storm track off the coast but close enough to bring some precipitation across central and eastern North Carolina.

By day 2, with the 00 UTC 12/24 and 12 UTC 12/24 runs, the models were in good agreement in significantly shifting the storm system far enough offshore to bring little if any precipitation across central North Carolina. This was a significant shift eastward and which suggested a low to no impact event in central North Carolina. The 18 UTC runs on 12/24 and the 00 UTC and 12 UTC runs on 12/25 then shifted the storm track westward and showed significant deepening. This track would bring a significant winter storm to the Carolinas. This solution would eventually verify fairly well and was close to the ECMWF forecast 6 to 7 days out.

The erratic nature of the NWP guidance with this event will like be a topic of research for several years to come. Researchers are suggesting that the large shift in the forecast track with the 00 UTC 12/24 and 12 UTC 12/24 runs may have originated from small initial condition uncertainties/errors in the short wave trough in the central and southern Plains. Small initial condition differences with the GFS and the ECMWF at 1200 UTC 12/24 appear to have amplified to large differences in the forecast 36-48 hours later.

Additional details on this winter storm and information on some research examining this type of storm is available from a project between the NWS and Stony Brook University. This project is entitled the *Predictability of High Impact Weather during the Cool Season over the Eastern U.S.* A website developed by this group provides a great deal of data and information on this winter storm.

Comparison of Ensemble Forecast Points
Forecasts from ensemble members of the ECENS (yellow), GEFS (red), CMCE (blue), SREF (green), and other operational models valid 00 UTC 12/27

72 hour forecast points
48 hour forecast points
24 hour forecast points

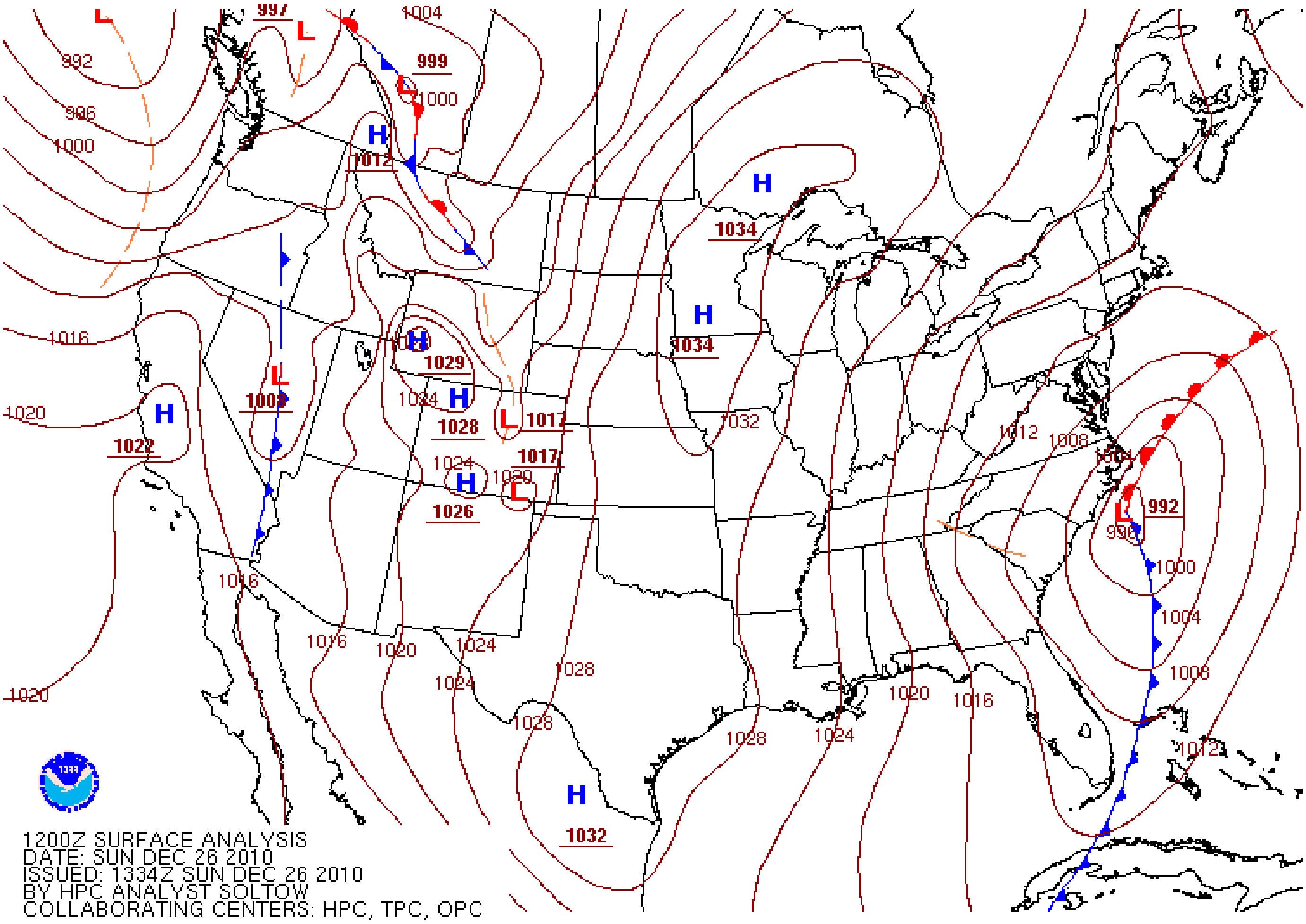
Comparison of HPC vs. SREF Snowfall Probabilities
24 hour total snow amounts valid 12 UTC 12/26 – 12 UTC 12/27

HPC Forecast issued 7 UTC 12/24 & SREF Forecast from 3 UTC 12/24
HPC Forecast issued 7 UTC 12/25 & SREF Forecast from 3 UTC 12/25
HPC Forecast issued 7 UTC 12/26 & SREF Forecast from 3 UTC 12/26

Surface Analysis

The surface pattern during the event was consistent with many past significant winter storms in central North Carolina with a storm system tracking northeast across the northern Gulf Coast and the Southeast U.S. coastalong with an arctic air mass centered across the eastern Great Lakes. The event followed a "Miller A" surface pattern in which a single well developed low pressure system develops in the Gulf of Mexico and tracks northeast across Florida before moving up the U.S. East Coast while rapidly deepening. "Miller A" events typically result in a simpler precipitation pattern that includes corridors of snow and rain with a well defined rain-snow line with little or no icing in the narrow transition zone.

A **Java Loop** of surface analysis imagery from 00 UTC on December 24 through 12 UTC on December 27, 2010 shows the evolution of the event. Note that the surface low track is in a favored location for significant winter storms in central North Carolina. In addition, the surface high pressure system was of sufficient strength (around 1035 MB) but centered west of the preferred location in the eastern Great Lakes region.

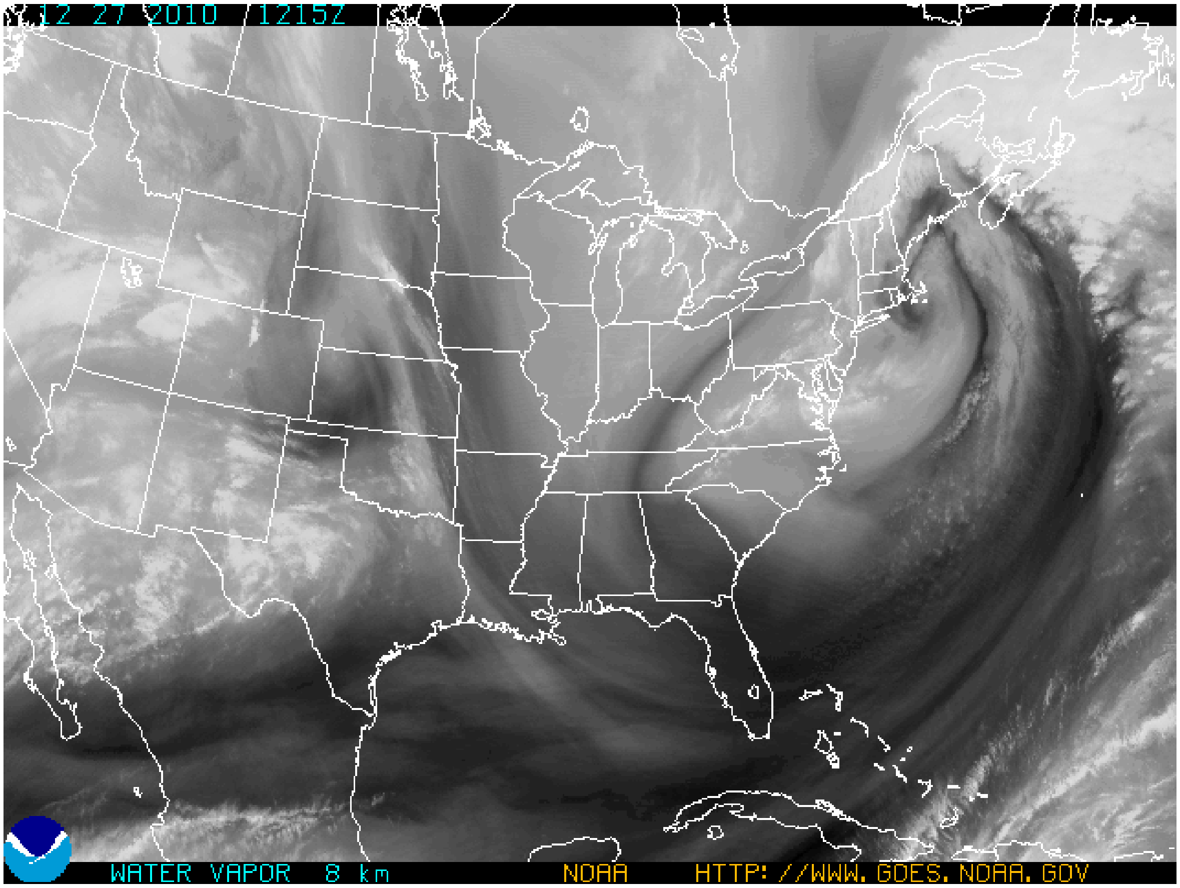


Satellite Imagery

Water vapor imagery was used to monitor the short wave troughs in both the northern and southern jet streams and to identify the potential phasing of the jet streams. The animation below contains hourly water vapor imagery from 0015 UTC December 24 through 1215 UTC December 27, 2010, a loop that the user can stop/start/change speeds is available able below.

In the loop below, a southern stream vortex can be seen moving east from the Desert Southwest region across Texas and to near the northern Gulf of Mexico through the morning of 12/25. At the same time, two short wave troughs can be seen moving southeast across the Missouri Valley. The second short wave trough reaches northern Arkansas by the morning of 12/25 with both troughs merging later that evening and initiating rapid cyclogenesis off the Southeast and Mid-Atlantic coast.

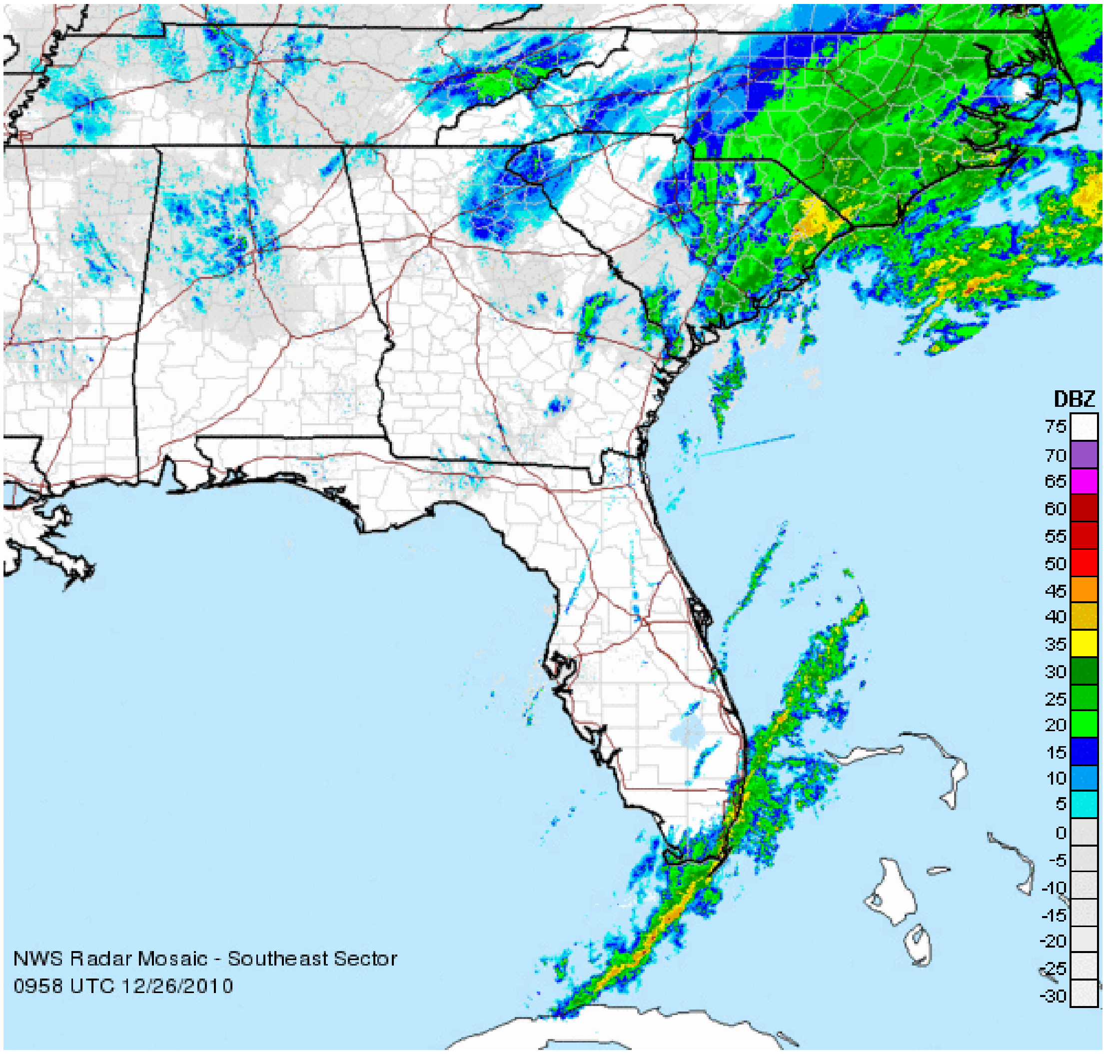
A **Java Loop** of water vapor imagery from 0015 UTC December 24 through 1215 UTC December 27, 2010 is available.



Southeast Regional Radar Imagery

Regional radar imagery shows the two different areas of precipitation that impacted central North Carolina during the event. These features can be seen in a **Java Loop** of Southeast regional radar imagery from 1158 UTC on December 25 through 1958 UTC on December 26, 2010.

The first area of precipitation which stretched southwest to northeast into western and northern North Carolina during the morning and afternoon hors on 12/25. This area of precipitation was largely driven by mid and upper level features and produced several inches of snow across western and northern North Carolina. The second area of precipitation which developed during the evening on 12/25 and continued overnight into the morning on 12/26 was associated with the merging upper level troughs and the deepening surface low off the coast. This precipitation was banded in nature and heavy at times and resulted in the majority of the accumulation across central and eastern North Carolina.



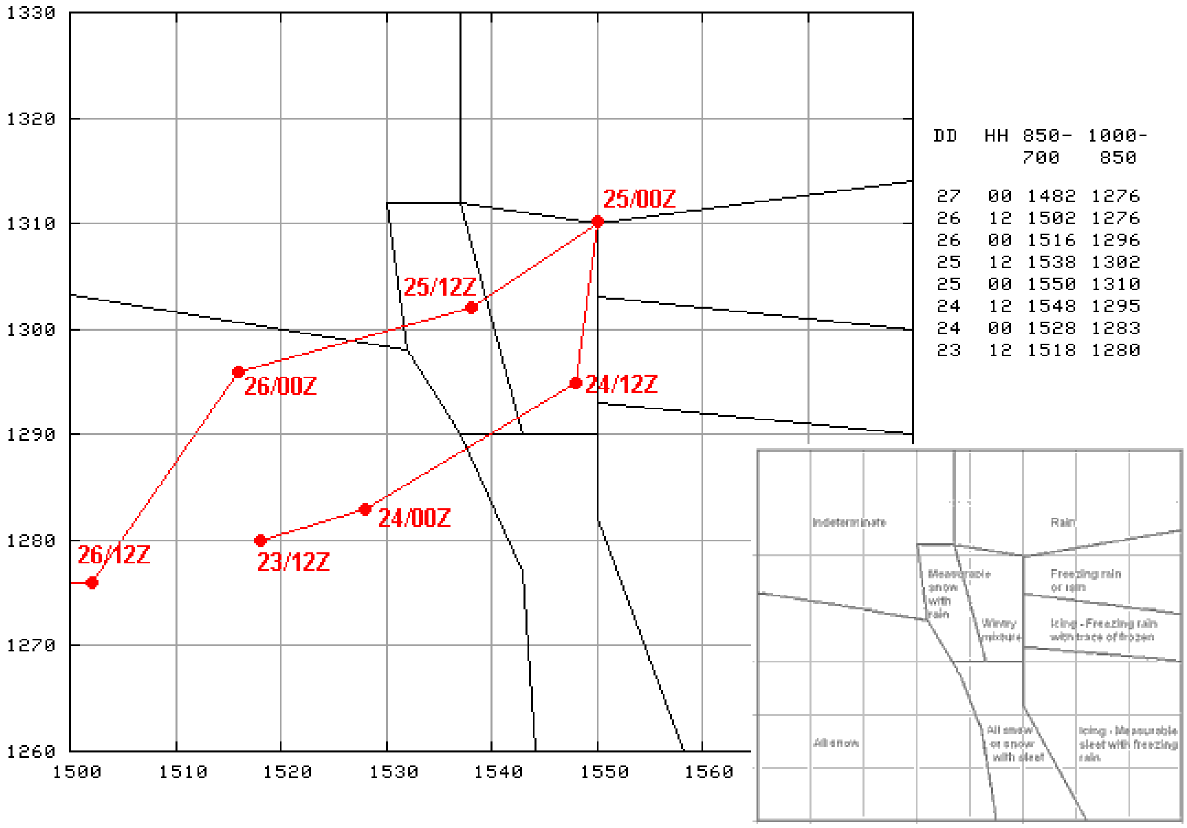
TREND's Predominant P-type Nomogram

The nomogram to the right shows the distribution of precipitation (p-type) TREND's as a function of partial thickness values. Close examination of precipitation events over the past 30 years accounts for the boundaries on the nomogram separating the various p-type areas. Mid level thickness values increase from left to right along the x axis. Low level thickness values increase from bottom to top along the y-axis.

This nomogram displays the observed thickness values from the 6 or 12 hourly RAOB's at KGSO from 12 UTC on 12/23 through 12 UTC on 12/26. Thickness values preceding the event gradually warmed through 12 UTC on 12/24 with a more significant low level warming during the afternoon of 12/24. Thickness values began to cool after 00 UTC on 12/25 with the greatest cooling occurring in the mid levels in the 850-700 mb layer which dropped 34 meters between 00 UTC on 12/25 through 00 UTC on 12/26; while the low level thickness values in the 1000-850 mb layer dropped only 14 meters. This is indicative of falling heights aloft while the low levels remained somewhat mild with little cool advection.

Light snow arrived at KGSO just after 16 UTC on 12/25 with surface temperatures in the upper 30s. Diabatic cooling from evaporation allowed surface temperatures to quickly drop to 33 degrees after the onset of precipitation. Subsequent diabatic cooling, likely from melting snow, allowed temperatures to fall to 32 degrees after 3 or 4 hours of precipitation. During this time, the predominate precipitation type nomogram when using thickness values from the 12 UTC 25 December KGSO RAOB and the 00 UTC 26 December KGSO RAOB was trending from "measurable snow with rain" toward "all snow." Greensboro officially received 5.8 inches of snow with the heaviest snow falling during the late afternoon on 12/25 with a steady but mainly light snow falling overnight through the late morning hours on 12/26.

GSO Thickness Plot



DD	HH	850-700	1000-850
27	00	1482	1276
26	12	1502	1276
26	00	1516	1296
25	12	1538	1302
25	00	1550	1310
24	12	1548	1295
24	00	1528	1283
23	12	1518	1280

Observations for GREENSBORO PIEDMONT, NC (GSO)

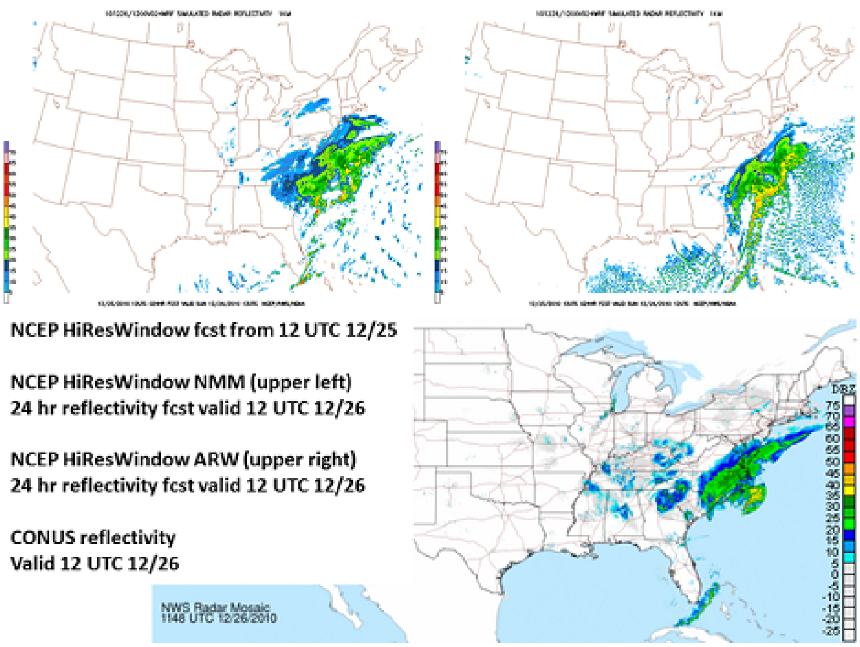
STN	TIME DD/HHMM	PMSL hPa	ALTM inHg	TMP F	DEW F	RH %	DIR deg	SPD kt	GUS kt	VIS mile	CLOUDS			Weather	MIN F	MAX F	P01 in	PCP in	SNO in
GSO	26/2354	1006.7	29.71	28	17	63	320	12		10.0	FEW055	BKN070	BKN110		27	31			4
GSO	26/2254	1006.3	29.70	28	18	65	310	13		10.0	BKN055	BKN075							
GSO	26/2154	1005.8	29.68	29	20	69	310	9		10.0	FEW031	OVC090							
GSO	26/2054	1005.3	29.67	31	21	66	320	10		10.0	SCT031	BKN042	OVC095						
GSO	26/1954	1005.1	29.66	31	23	72	320	11		10.0	FEW024	BKN033	OVC040						
GSO	26/1854	1005.3	29.67	31	23	72	330	6		10.0	OVC036								
GSO	26/1754	1006.2	29.70	31	22	69	340	7		10.0	SCT027	BKN042	BKN095		27	31		0.02	5
GSO	26/1654	1007.2	29.73	29	23	78	350	8		10.0	OVC042						0.00		
GSO	26/1554	1008.3	29.75	28	22	78	340	7		4.0	FEW015	BKN031	OVC042	S-			0.00		
GSO	26/1454	1008.9	29.78	28	23	81	350	8		3.0	OVC029			S-			0.00	0.02	
GSO	26/1354	1008.6	29.77	28	24	85	10	6		2.0	FEW010	BKN015	OVC023	S-F			0.00		
GSO	26/1254	1008.3	29.76	27	24	89	10	8		2.0	OVC012			S-F			0.02		
GSO	26/1154	1008.1	29.75	27	24	89	30	10	16	1.8	SCT010	BKN014	OVC018	S-F	27	30	0.00	0.10	5
GSO	26/1054	1007.9	29.75	28	24	85	40	11		1.5	FEW010	OVC017		S-F			0.02		
GSO	26/0954	1008.7	29.77	28	25	88	40	9		1.2	BKN011	OVC017		S-F			0.03		
GSO	26/0854		29.76	28	25	86	30	8		0.5	SCT006	OVC013		SIF					
GSO	26/0754	1009.0	29.78	29	26	89	40	9	17	0.8	BKN007	OVC011		S-F			0.02		
GSO	26/0654	1009.9	29.80	29	26	89	40	9		2.0	BKN008	OVC011		S-F			0.00		
GSO	26/0554	1010.6	29.83	30	27	88	20	9		2.5	OVC008			S-F	30	32	0.01	0.21	4
GSO	26/0454	1011.3	29.85	30	28	92	20	7		1.2	BKN008	OVC018		S-F			0.01		
GSO	26/0354	1012.2	29.88	30	28	92	20	7		1.0	OVC006			S-F			0.04		
GSO	26/0254	1012.6	29.89	31	28	89	40	6		0.8	OVC006			S-F			0.03	0.15	
GSO	26/0154	1012.8	29.89	31	29	92	40	8		0.8	BKN003	BKN008	OVC014	S-F			0.04		
GSO	26/0054	1013.4	29.91	32	30	92	30	4		0.8	BKN003	BKN010	OVC014	S-F			0.08		
GSO	25/2354	1013.5	29.91	32	30	92	30	4		0.8	OVC003			S-F	32	33	0.06	0.33	3
GSO	25/2254	1013.2	29.90	32	31	96	50	5		0.8	OVC005			S-F			0.07		
GSO	25/2154	1013.6	29.92	32	31	96	80	3		0.5	OVC002			SF			0.06		
GSO	25/2054	1013.8	29.92	32	30	92	80	4		0.2	OVC004			S+F			0.06	0.14	
GSO	25/1954	1014.5	29.94	33	31	92	0	0		0.2	OVC004			SF			0.05		
GSO	25/1854	1014.1	29.93	33	30	88	40	4		0.5	BKN003	OVC019		SF			0.03		
GSO	25/1754	1015.4	29.97	33	30	88	320	3		0.8	X006			S-F	33	40	0.02	0.02	
GSO	25/1654	1016.0	29.99	38	25	59	0	0		3.0	OVC021			S-			0.00		
GSO	25/1554	1016.3	30.00	39	18	42		3		10.0	BKN050	BKN080							
GSO	25/1454	1016.6	30.01	37	18	46	0	0		10.0	SCT070	BKN090							
GSO	25/1354	1016.5	30.00	36	18	48	60	4		10.0	FEW065	BKN095							
GSO	25/1254	1016.8	30.01	34	19	54	80	5		10.0	BKN100								
GSO	25/1154	1017.4	30.03	34	19	54	70	5		10.0	OVC090				34	36			

High Resolution Model Reflectivity Data

Comparison of NCEP High Res WRF-NMM and WRF-ARW with Observed Radar Reflectivity

An example image along with a tabular comparison of forecast reflectivity imagery from the NCEP High Res WRF NMM, WRF ARW, and observed CONUS radar reflectivity for the December 25-26 Winter Storm is shown below. A [power point presentation contains a full set of comparison images](#).

During this event, forecasters used hourly and 3 hourly output from the NCEP High Resolution WRF NMM and ARW models along with the NCEP WRF-NMM run for the SPC, the NSSL WRF-ARW run, and runs from the WFO RAH WRF-NMM simulations successfully. They found the hourly and 3 hourly data to be very helpful in examining precipitation and QPF trends and in identifying mesoscale features. For example, narrow progressive banded structures are easier to identify and examine in hourly or 3 hourly output. These features get smeared out and are difficult to resolve in 6 hourly output.



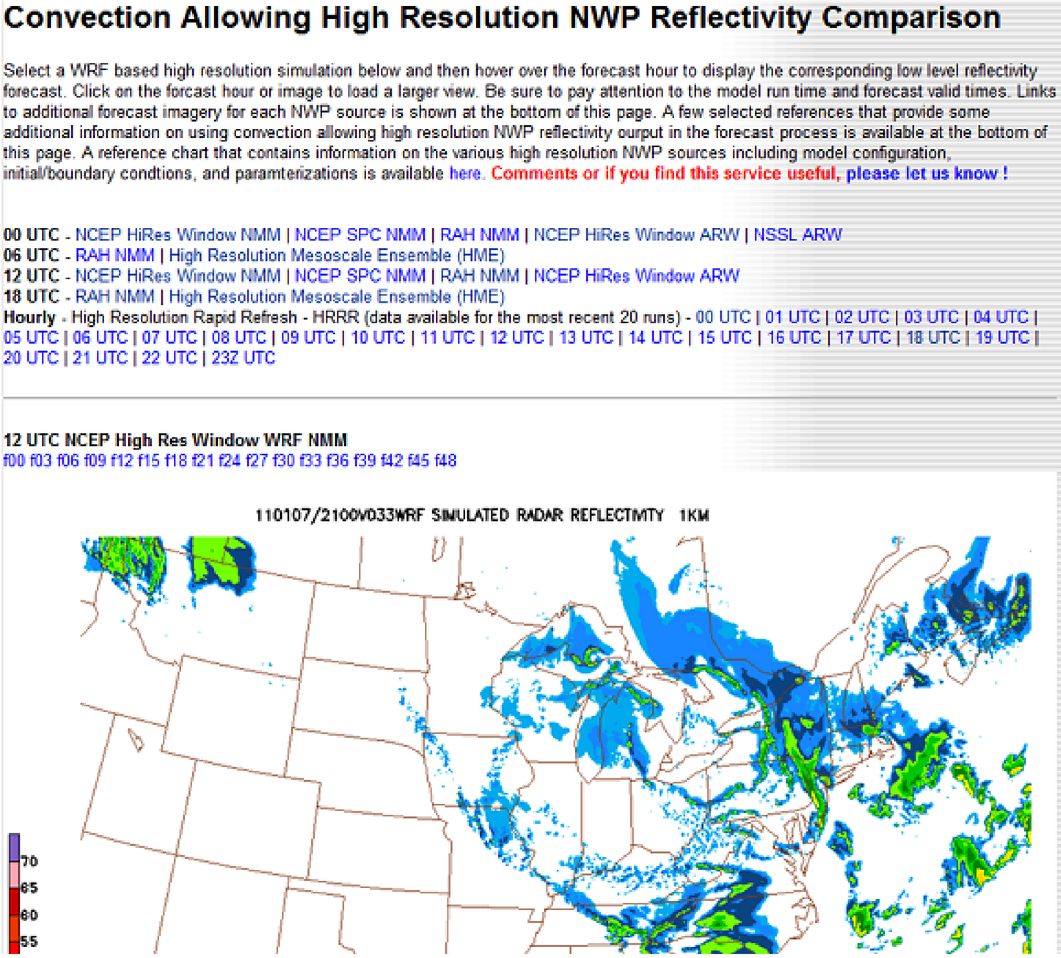
NCEP HiResWindow forecasts verifying at 00 UTC 12/26
48 hour fcst from 00 UTC 12/24 | 36 hour fcst from 12 UTC 12/24 | 24 hour fcst from 00 UTC 12/25 | 12 hour fcst from 12 UTC 12/25

NCEP HiResWindow forecasts verifying at 12 UTC 12/26
48 hour fcst from 12 UTC 12/24 | 36 hour fcst from 00 UTC 12/25 | 24 hour fcst from 12 UTC 12/25 | 12 hour fcst from 00 UTC 12/26

NCEP HiResWindow forecasts verifying at 00 UTC 12/27
48 hour fcst from 00 UTC 12/25 | 36 hour fcst from 12 UTC 12/25 | 24 hour fcst from 00 UTC 12/26 | 12 hour fcst from 12 UTC 12/26

High Resolution Model Reflectivity Forecast Comparison Web Page

Recent research has shown that convection allowing high resolution NWP reflectivity forecasts can be useful in the forecast process when used appropriately. In order to facilitate the use of high resolution NWP reflectivity forecasts, the NWS Raleigh created the **High Resolution Model Reflectivity Forecast Comparison Web Page**. This pages allows users to easily compare NCEP High Resolution WRF NMM and ARW models along with the NCEP WRF-NMM run for the SPC, the NSSL WRF-ARW run, and runs from the WFO RAH WRF-NMM simulations. A snap shot of the web page is shown below.



Hourly 4 inch (0.1m) Soil Temperatures

The image below (click on it to enlarge) shows the hourly 4 inch soil temperatures at 8 locations across central North Carolina from midnight on 12/24 through midnight on 12/30, 2010.

First, note that the 4 inch soil temperatures were rather cold on 12/24, with soil temperatures at most locations dropping into the mid 30s or colder on the morning of 12/24. Despite mostly sunny skies during the day and high temperatures mainly in the lower to mid 40s, soil temperatures only warmed slightly from the morning minimums with a diurnal spread of between 4 and 8 degrees on 12/24. The nocturnal cooling of the soil was likely reduced by the warmer air temperatures compared to previous nights. Air temperatures on the morning of 12/25 ranged in the lower to mid 30s with mostly cloudy skies.

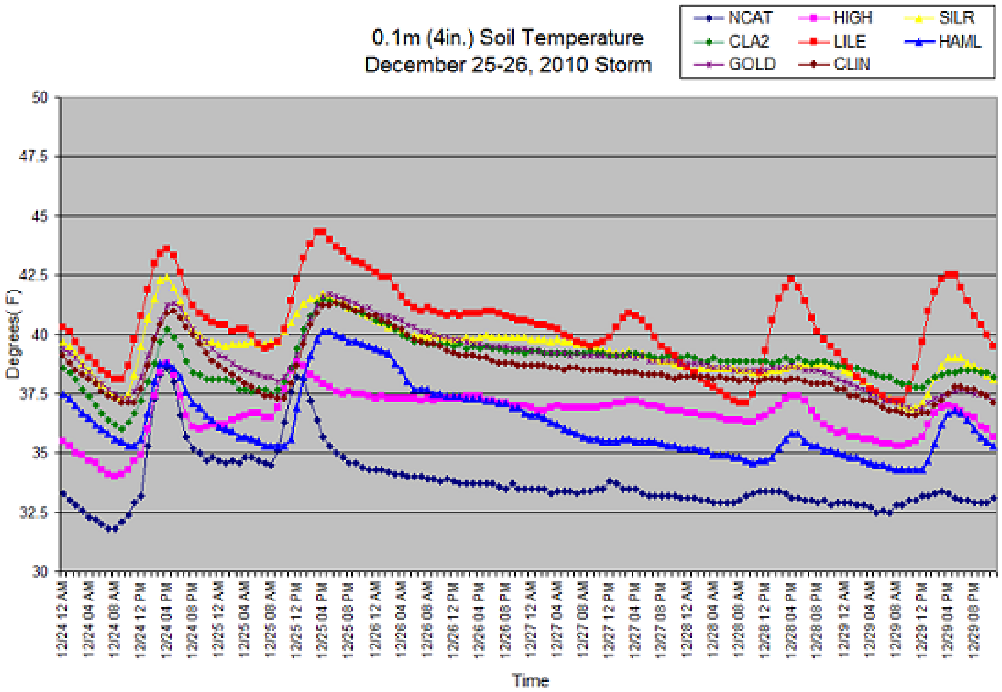
Precipitation spread into the western Piedmont during the late morning hours on 12/25. The precipitation was responsible for the early peak in the hourly soil temperature plot for stations NCAT (NC A&T Research Farm) and HIGH (UNCG Lindale Farm Station) which are both located in Greensboro. Note that the max soil temperature for these two locations occurred around noon local time. The other stations reached their maximum soil temperature around the more typical time of 400 PM local time.

In general, most locations had a rather steady decline in soil temperatures as precipitation fell across central North Carolina. Note that both LILE (Lilesville) and HAML (Hamlet) had a more aggressive decline in soil temperatures between 200 AM and 600 AM. This decline appears coincident with a period of heavier precipitation which cooled the boundary layer and allowed the rain to quickly change to snow and accumulate during the pre dawn hours. It is also worth noting that there was very little diurnal change in soil temperatures on 12/26 as snow accumulated across most of central North Carolina through at least midday

On 12/27, the soil temperatures at most observing locations in central North Carolina showed very little diurnal change. This was not too surprising given the fresh snow cover across the area. Note that there was one exception, LILE which had around a 3 degree diurnal change in soil temperatures during the day. South-central NC where Lilesville is located, received around 4 inches of snow during the storm which was on the low end of the general 4 to 12 inches of accumulation that fell across central NC. In addition, high temperatures on 12/27th approached 40 degrees in Lilesville which resulted in some additional melting.

By 12/28, sunshine along with daytime temperatures well into the 40s resulted in considerable melting and allowed the diurnal spread in soil temperatures to increase. The diurnal spread was greatest at LILE, HAML, and in Greensboro at the NCAT and HIGH where the snow melted more significantly compared to CLIN (Clinton), GOLD (Goldsboro), CLA2 (Clayton) and SILR (Siler City) where the more significant snows were slower to melt.

Past experience has shown that when the max soil temperature during the day preceding a snow fall are in the lower 40s or colder and given modest snow rates with surface temperatures at or near freezing, the snow can be expected to accumulate. Max soil temperatures in most of central North Carolina were in the lower to mid 40s on 12/24. During this event, the snow was slower to accumulate than then 12/16, 2010 event which had very cold temperatures preceding and during that event which allowed the snow to readily accumulate, even on roadways. During this event, boundary layer temperatures in the eastern Piedmont and Coastal Plain were near or just above freezing which initially limited accumulations. Eventually, heavier precipitation and cooling from melting allowed air temperatures to fall to around or below freezing and allow the snow to accumulate more efficiently.



NCAT - NC A&T Research Farm, Greensboro NC
HIGH - UNCG Lindale Farm Station, Greensboro NC
SILR - Siler City Airport, Siler City, NC
CLA2 - DAQ Clayton Profiler, Clayton, NC
LILE - NC Electric Cooperative Anson Peaking Plant, Lilesville, NC
HAML - Hamlet Tower, Hamlet, NC
GOLD - Cherry Research Station, Goldsboro, NC
CLIN - Horticultural Crops Research Station, Clinton, NC

CoCoRaHS Observer Network

CoCoRaHS is a grassroots volunteer network of weather observers working together to measure and map precipitation (rain, hail and snow) in their local communities. By using low-cost measurement tools, stressing training and education, and utilizing an interactive web-site, CoCoRaHS aims to provide the highest quality data for natural resource, education and research applications. The only requirements to join are an enthusiasm for watching and reporting weather conditions and a desire to learn more about how weather can effect and impact our lives. North Carolina joined the CoCoRaHS network in 2007. For more information, visit the CoCoRaHS web site at www.cocorahs.org.

The CoCoRaHS Web page provides the ability for CoCoRaHS observers to see their observations mapped out in "real time", as well as providing a wealth of information for our data users. The snow accumulation maps from the CoCoRaHS web site (shown below) were a great resource for WFO RAH. The CoCoRaHS observers in central North Carolina were notified of the potential storm in advance and encouraged to report during the event. Observations from the CoCoRaHS observers were excellent and very timely.

CoCoRaHS Intense Snow Report

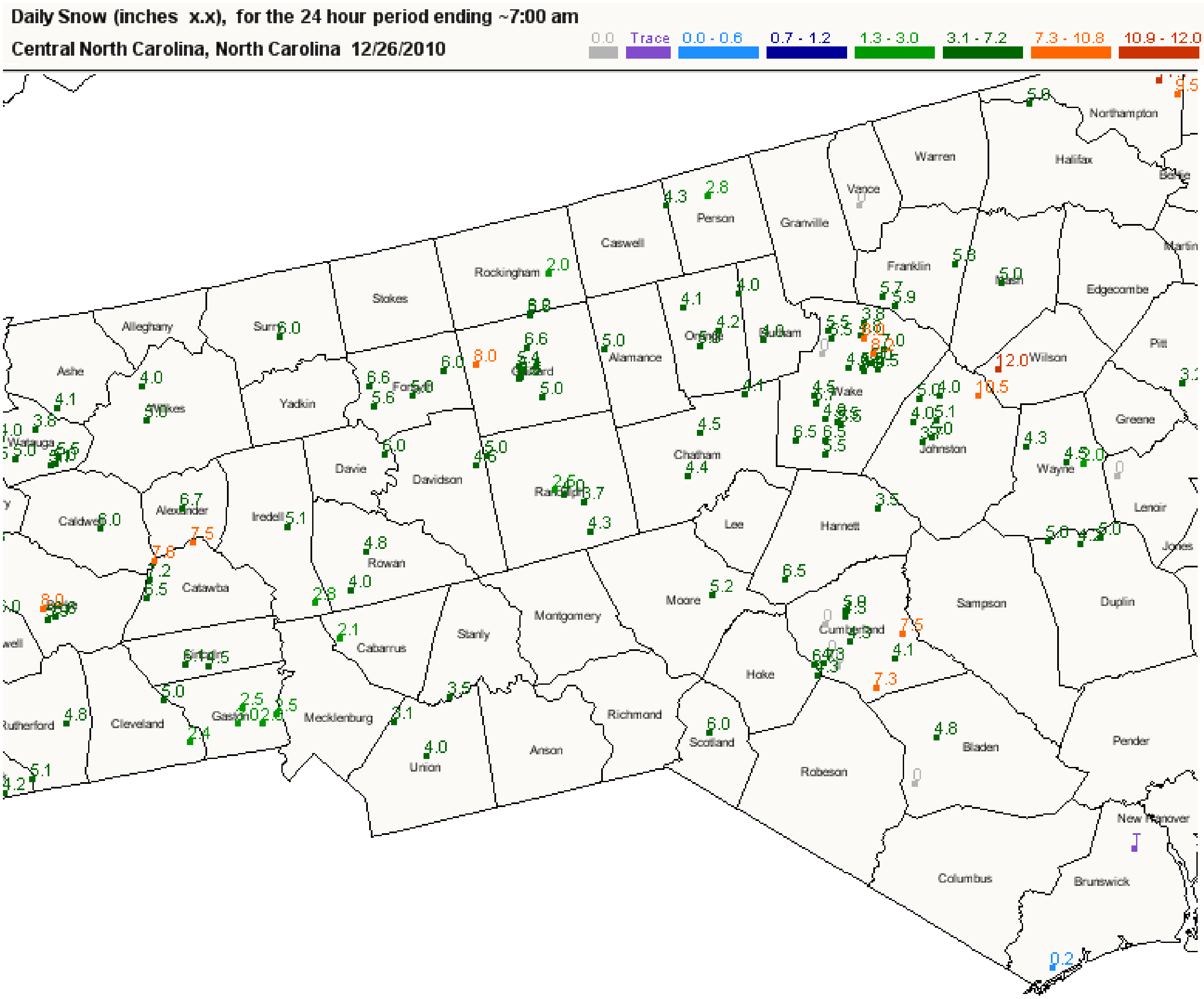
NWS Raleigh received 45 CoCoRaHS Intense Snow Reports during this winter storm. An example is shown below with all of the reports available here. The intense snow reports are extremely helpful since it can be difficult to get accurate snow accumulation reports during the event and especially at night. Several of the Intense Snow Reports were received late in the evening or overnight when it is very difficult to get reliable information. The value of these reports cannot be overstated.

```
NZUS45 KBOU
CCRAHS

Intense snow report from CoCoRAHS spotter:

12/26/2010 01:30 AM local time
County: Randolph NC
Asheboro 2.2 SSE (number NC-RN-1)
Latitude: 35.6892
```

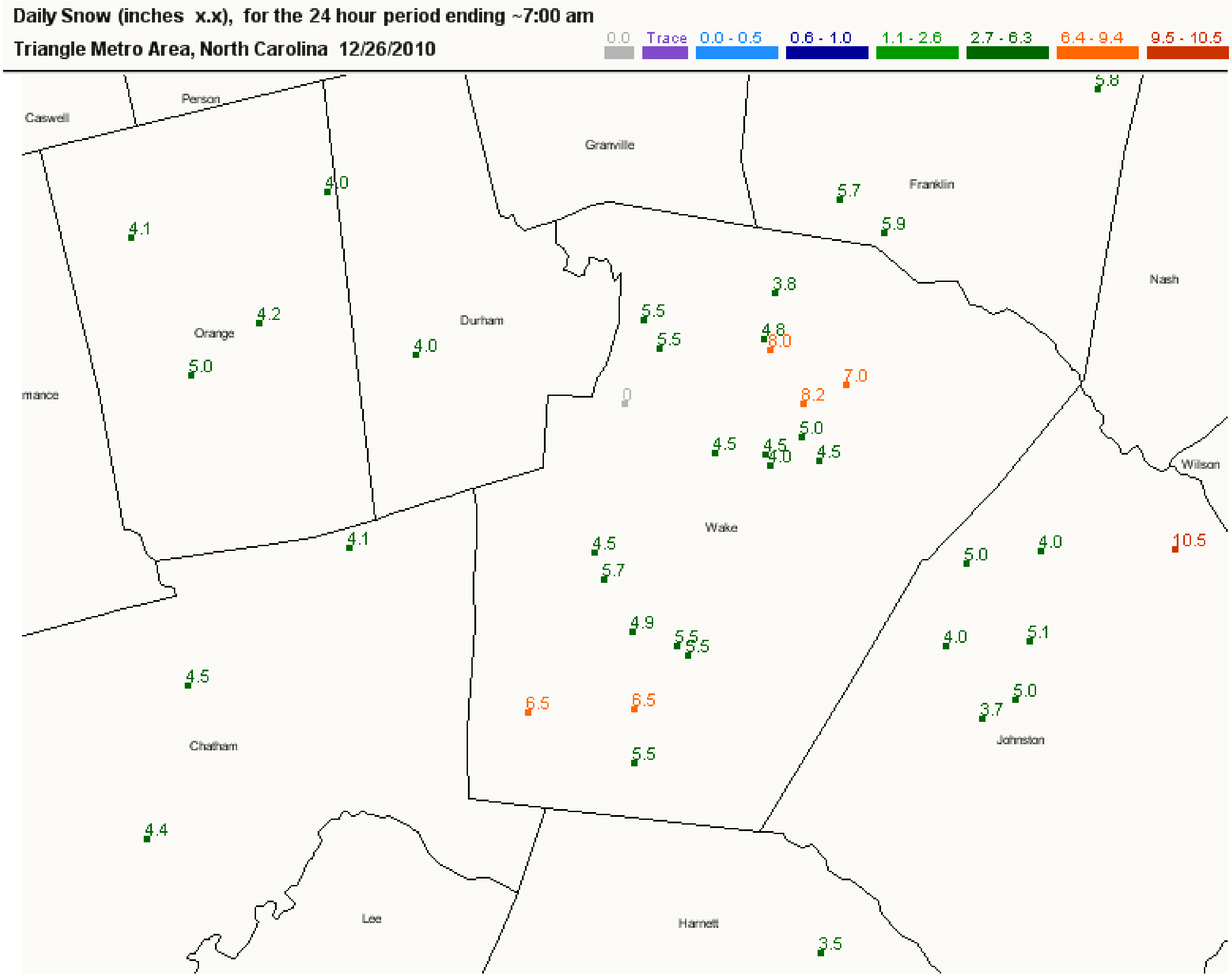
Longitude: -79.801
0.50 inches of snowfall in the past 20 mins
1.50 inches of snow on the ground
Comments: Moderate snow. 31 degrees. 1.5 inches on the ground. Snow has covered the roads during the last 20 minutes.

Received NWS Boulder Sat Dec 25 23:33:53 2010 MST
Sent to WFOs: RAH

Central North Carolina Snow Accumulation Totals Ending at 7AM on 12/26



Triangle Area Snow Accumulation Totals Ending at 7AM on 12/26



Archived Text Data from the Winter Storm

Select the desired product along with the date and click "Get Archive Data."
Date and time should be selected based on issuance time in GMT (Greenwich Mean Time which equals EST time + 5 hours).

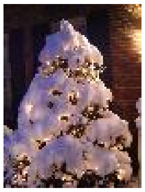
Product ID information for the most frequently used products...

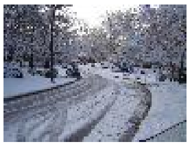
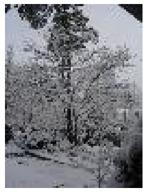
RDUAFDRAH - Area Forecast Discussion
RDUAFMRAH - Area Forecast Matrices
RDUHWORAH - Hazardous Weather Outlook
RDUNOWRAH - Short Term Forecast
RDUPFMRAH - Point Forecast Matrices
RDUPNSRAH - Public Information Statements (snow/ice reports among other items.)
RDUWRKDRT - Soil Temperature Data from the NC State Climate Office
RDUWSWRAH - Winter Storm Watch/Warning/Advisory
RDUZFPRAH - Zone Forecast Products

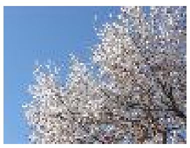
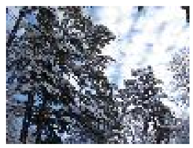
* Scroll down for list | from | December | 27 | 2010

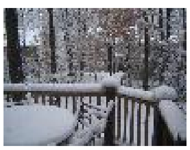
Get Archive Data

Select Photos of the Winter Storm
Photos courtesy of William Wilson and Jonathan Blaes

Final Thoughts and Lessons Learned

Forecasters were challenged with evolving NWP guidance which had great difficulty in predicting the storm intensity and location, especially during the 00 UTC and 12 UTC 12/24 runs. The difficultly was centered around whether the northern and southern jet streams would phase which would dictate whether the storm was weak and moved out to sea or whether the storm significantly intensified and moved up the East Coast.

Predicting the phasing of the northern and southern jet streams can be problematic. For this event, the NWP guidance struggled with an event that was 36-60 hours out, while the short wave troughs were entrenched in the land based RAOB network. The careful approach used by forecasters at WFO RAH was to be cautious about jumping on the event in the long term but rather gradually step into or trend the forecast toward a stormier solution. When the guidance backed away from as significant storm, forecasters did not make wholesale changes but rather trend the forecast. As the event drew closer, forecasters used observational data and pattern recognition to jump on the storm and issue timely winter storm watches. Despite the changes in model and HPC guidance, forecasters did not sway making large day to day changes with the forecast. We began conservatively 6-7 days out, introduced the threat of a winter storm, trended toward a drier solution 2-3 days out, and then trended back toward a winter storm on Christmas Eve.

Two web based tools were helpful for forecasters while evaluating model trends:
- The HPC medium range desk blender was insightful to objectively examine HPC's extended range thoughts (look under the "New Graphics Description).
- The EMC Cyclogenesis Tracking Page was also helpful in monitoring forecasts of the surface cyclone.

The limitations with deterministic forecasts and guidance along with the utility of probabilistic forecasts were very obvious with this event. A few days ahead of the storm we had a high confidence of some light snow, moderate confidence of some decent snow accumulations although the locations were unclear, and small but non zero chances of a very big storm. A single deterministic forecast of 2-4 inches doesn't really help in these situations.

Numerous briefings (example from 600 AM 12/25) were provided to local emergency managers and decision makers during the event via the NWS Raleigh Briefing Web Page and via other online conferencing software. The ability to share information with users who may be at home or away from the office was invaluable.

During this event, forecasters used hourly and 3 hourly output from the NCEP High Resolution Window WRF NMM and ARW models along with the NCEP WRF-NMM run for the SPC, the NSSL WRF-ARW run, and runs from the WFO RAH WRF-NMM simulations successfully. They found the hourly and 3 hourly data to be very helpful in examining precipitation and QPF trends and in identifying mesoscale features. For example, narrow progressive banded structures are easy to identify and examine in hourly or 3 hourly output.

These features get smeared out and difficult to resolve in 6 hourly output.

Forecasters effectively used some new tools during the forecast process including SREF Bufkit soundings displaying an ensemble of output from the p-type nomogram, plumes of ensemble precipitation forecasts, time-lagged ensembles of precipitation forecasts for one location in a dProg/dt sense, as well as additional SREF probabilistic fields from the SREF viewer application.

WFO RAH issued 274 LSR's from 300 PM on December 25th through 1159 PM on December 26th. In addition, there were 18 PNS' issued from 730 PM on December 25th through 1200 AM on December 27th with PNS' issued nearly every hour from midnight to noon on December 26th. Users were very happy to get snow accumulation reports in real time via the LSR product which allowed them to plot reports directly and in real time along with complete hourly summaries in the PNS.

NWS Raleigh received 45 CoCoRaHS Intense Snow Reports during this winter storm. These reports are especially important since it is very difficult to get accurate snow accumulation reports late at night. The value of these reports cannot be overstated.

Acknowledgements

Many of the images and graphics used in this review were provided by parties outside of WFO RAH. CONUS snowfall estimates provided by the National Operational Hydrologic Remote Sensing Center. MODIS imagery provided by the Space Science and Engineering Center - University of Wisconsin-Madison. Model comparison charts, comparison of ensemble forecast points, and comparison of HPC vs. SREF snowfall probabilities provided by SUNY Stony Brook CSTAR project and Dan Petersen. The surface analysis imagery was obtained from the Hydrometeorological Prediction Center. Satellite data was obtained from the National Center for Atmospheric Research. The upper air analysis images and Skew-T diagrams were obtained from the Storm Prediction Center. The University of Wyoming, and the Earth System Research Laboratory - Global Systems Division. AMDAR aircraft sounding data was obtained from the Earth System Research Laboratory - Global Systems Division. Surface observations provided by the University of Wyoming. Radar imagery was obtained from the National Weather Service web site. Ground temperatures and adjacent air temperature data provided by CRONOS from the N.C. State Climate Office. CoCoRaHS maps were provided by the CoCoRaHS organization. Photographs courtesy of William Wilson and Jonathan Blaes.

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