The December 16-17, 2020 snow and December 25th meltdown flood

Part 1: The snowstorm

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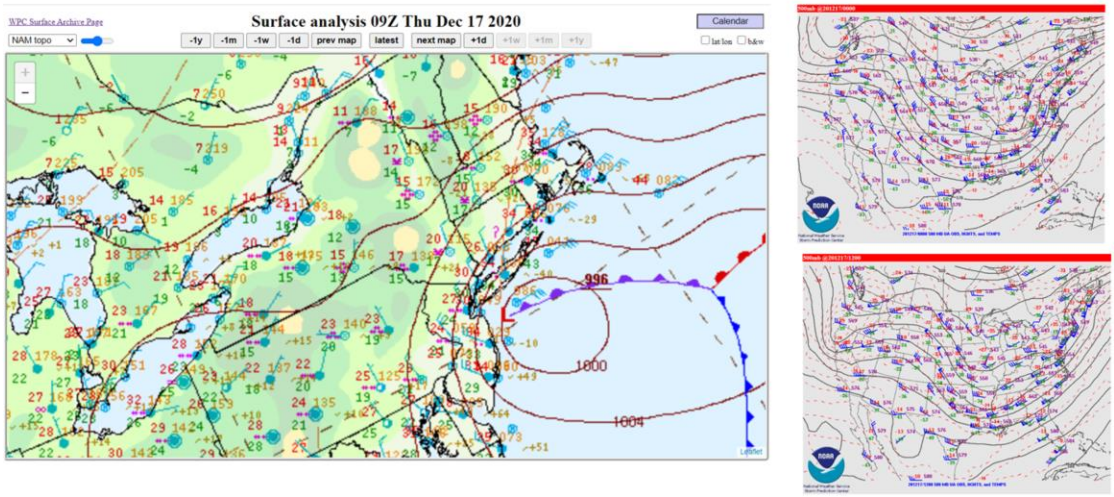
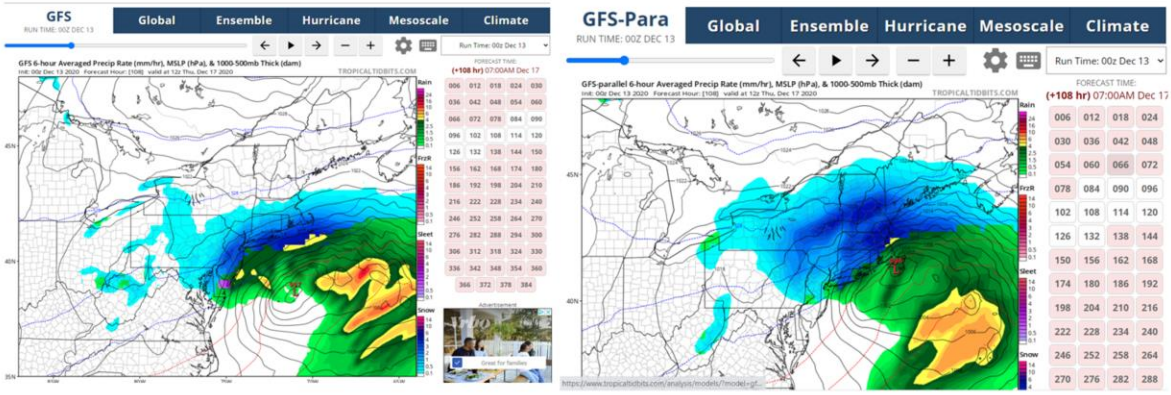
WFO Albany, NY

Mean sea-level pressure 09z and 500 mb analysis 00z and 12z December 17



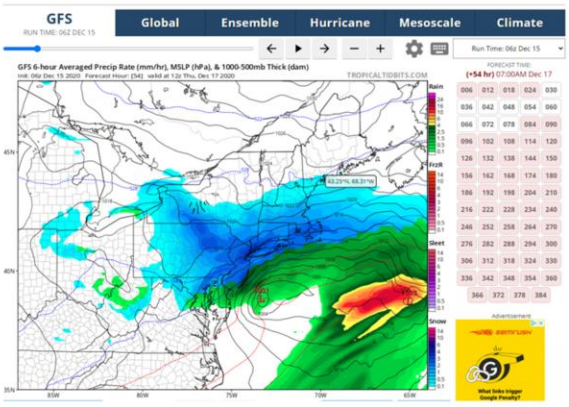
Low pressure developed along the mid-Atlantic coast early on the 17th. This storm produced historically high snowfall amounts across much of eastern NY and western New England, despite no rapid deepening, and a rather flat, de-amplified flow at 500 mb.

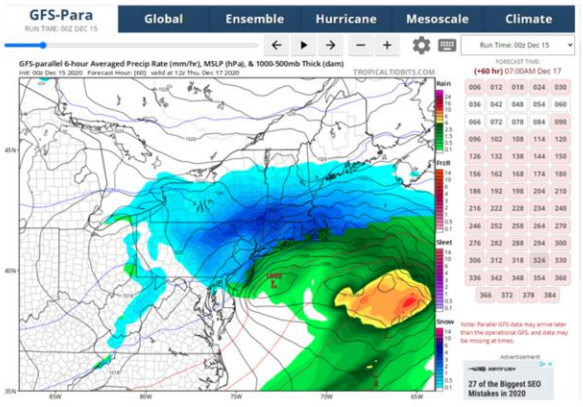
13th 00z GFS and parallel GFS



Model guidance indicated a large spread of possible solutions for our area on the 13th, 4 days prior to the event. Our operational GFS model was forecasting heavy snow for New Jersey and Long Island at this time, while the parallel GFS (scheduled to be operational in February) showed a band of heavy snowfall across east central NY into central New England.

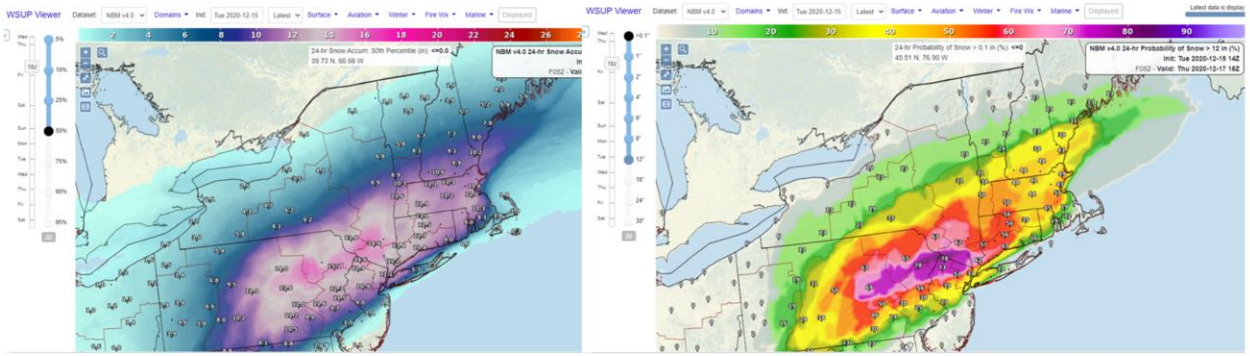
15th 00z GFS and parallel GFS





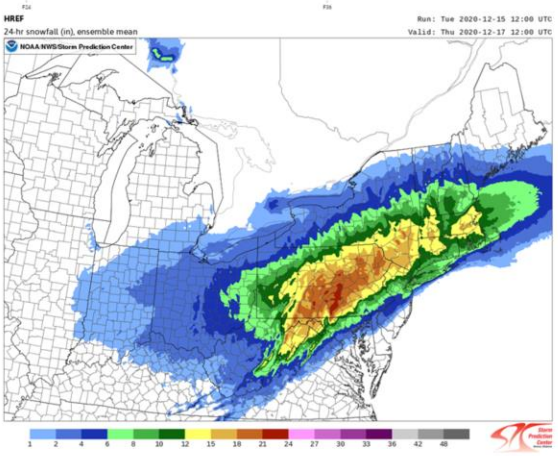
By 00z on the 15th, the operational and parallel GFS were slightly more similar, however the parallel GFS was still showing heavy snow farther to the north.

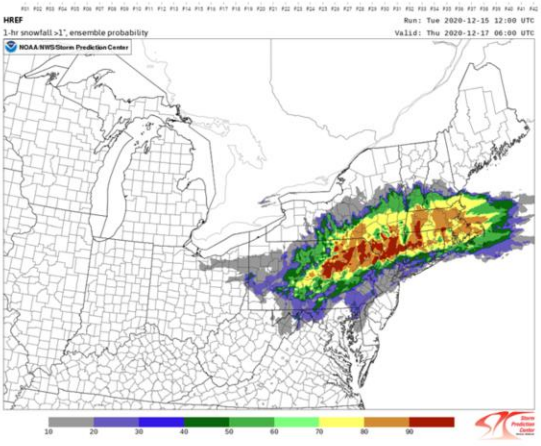
15th 12z National Blend of Models



The 12z 15th national blend of models, which is a large ensemble of operational models, including models of higher and lower resolution, was indicating that the heaviest snowfall would be from eastern Pa to northern New Jersey to southern New England. Probablities were high across this area for over a foot of snow. Probabalities for over a foot of snow in the Capital District of east central NY were about 30 to 40 percent.

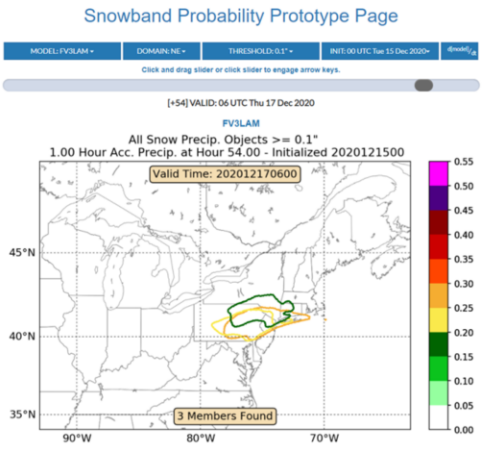
15th 12z HREF

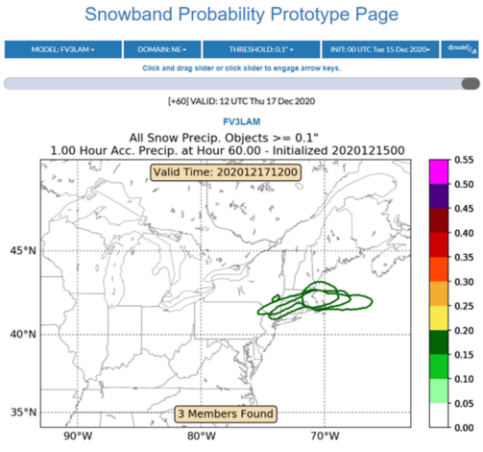




The 12z 15th run of the high resolution ensemble forecast (HREF), which is a relatively small ensemble of models with resolutions of 3 km, was similar to the national blend of models in that it indicated a band of heaviest snowfall from eastern Pa across the mid-Hudson Valley and southern New England (left). Highest probabalities for snowfall rates of greater than 1 inch per hour during the early morning hours on the 17th were likewise forecast from northeast Pa to southern New England.

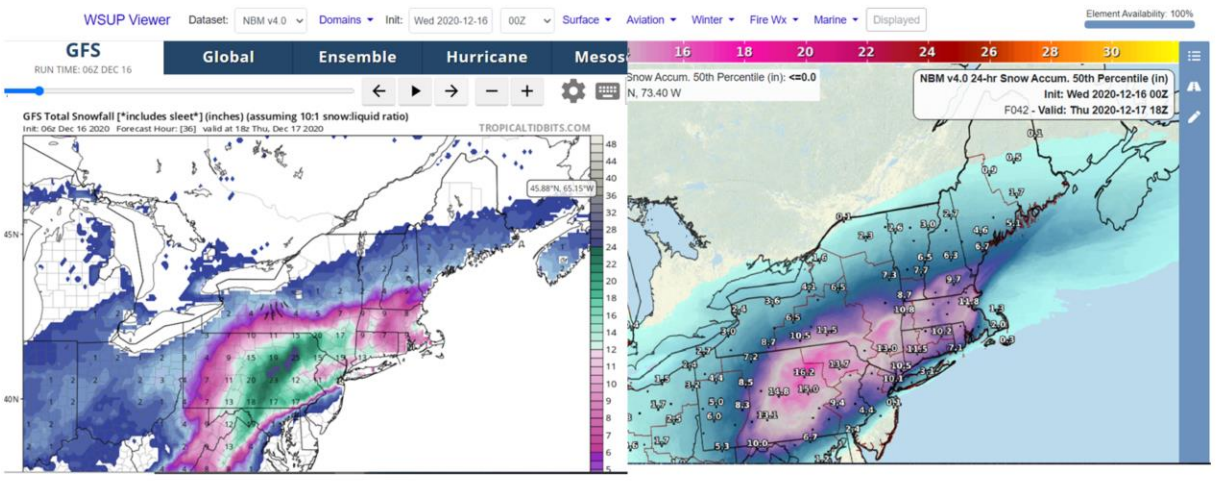
WPC band finder – based on 00z 15th 3 km FV3-based LAM (CAM)





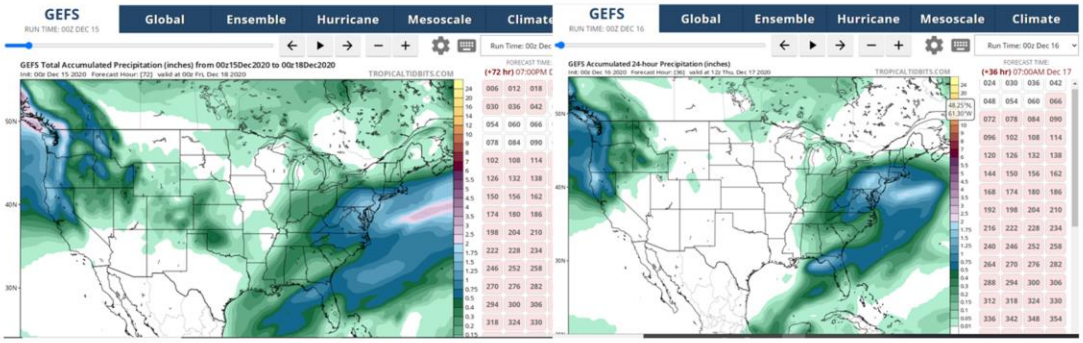
The WPC band finder highlights banded snowfall potential by showing locations where liquid precipitation values of greater than various thresholds per hour are forecast, in the form of snow. The 00z 15th version of the band finder based on the LAM high-resolution model, highlighted enhanced banding potential from northeast Pa across southern New England.

16th 00z GFS and National Blend of Models



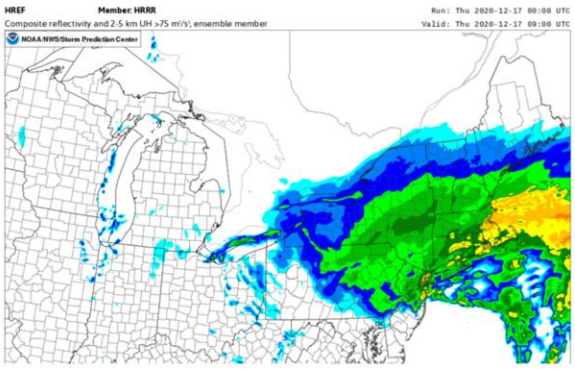
By 00z on the 16th, the GFS was slowly trending north with heaviest snowfall. Likewise, the national blend of models was trending slowly northward, however heaviest snowfall from both guidance sources was still shown from northeast Pennsylvania to the mid-Hudson Valley to southern New England.

GEFS mean QPF - 00z 15th and 00z 16th



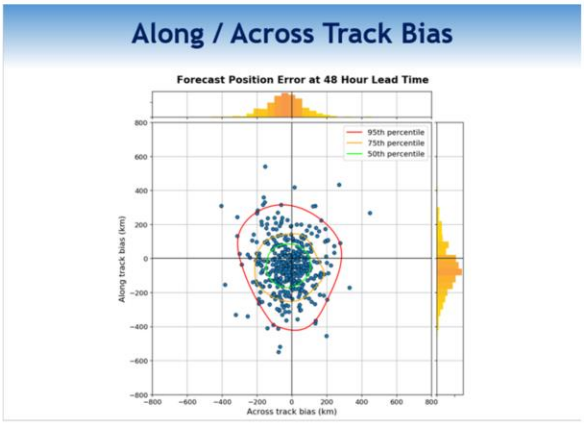
The GEFS, an operational ensemble of GFS forecasts, was also trending slowly northward from 00z on the 15th to 00z on the 16th.

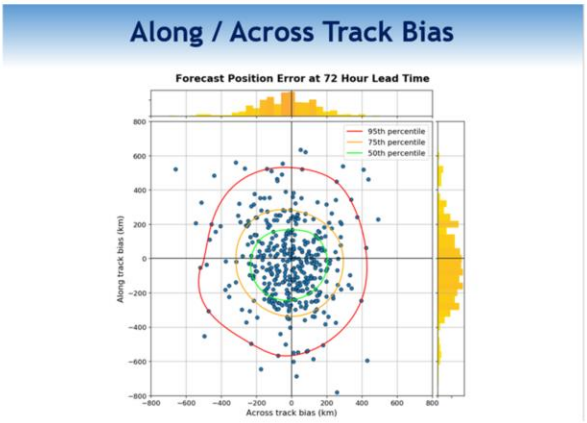
00z 17th December HRRR and NAM 3km



Finally, at 00z on the 17th, less than 6 hours before heavy snow began falling in the Capital District, Saratoga region, Berkshires and southern Vermont, Heaviest snow was now forecast along the I-88 corridor from near Binghamton, to Albany, to west central New England. On this slide, the 3 km NAM nest forecast is shown on the left, and the HRRR is shown on the right.

CSTAR research on GEFS model biases

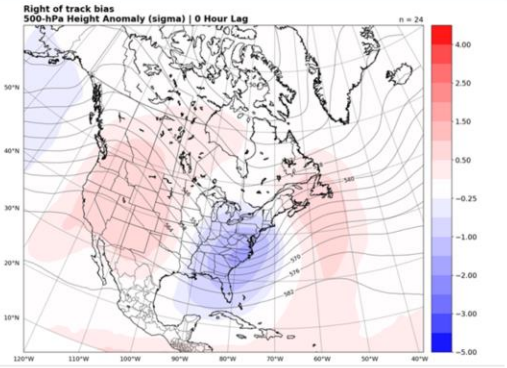




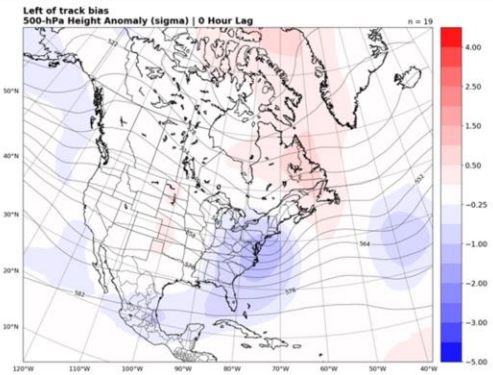
The northward trend in the guidance prior to this storm has been seen many times in our area for high-impact winter weather events, most recently during the March 14, 2017 major snowstorm. However, this trend does not occur for all storms. The graphs on this slide show results from research from CSTAR grant by Tomer Burg. Each point on the graphs are associated with GEFS forecasts of a western Atlantic storm. Storms plotted on the right side of the graphs exhibited a rightward bias, similar to the December 16-17, 2020 storm, while storms plotted on the left side of the graphs exhibited a leftward bias. These charts show a roughly even spread between leftward and rightward biased storms during the several year period of study.

CSTAR research on right of track bias (like December 16-17) vs. left of track bias events

Composites

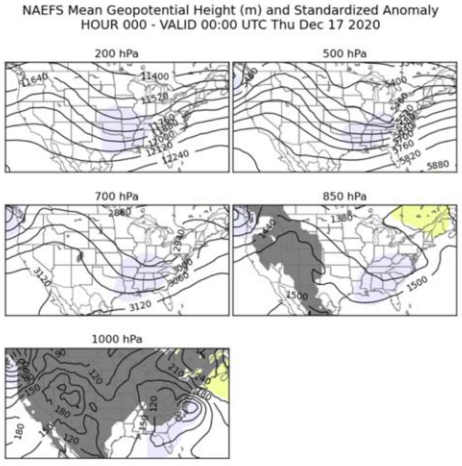


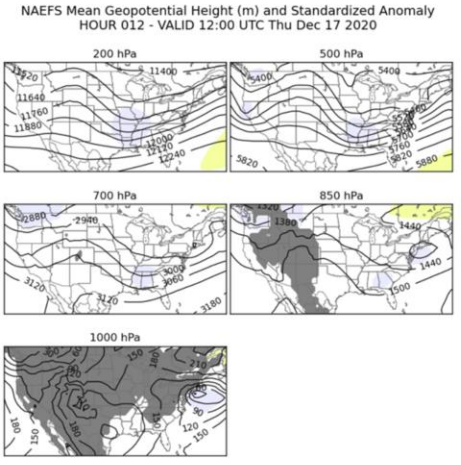
Composites



Composites of the 500 mb heights for the rightward biased storms show a pronounced ridge over the western U.S. Storms with a leftward bias had a flatter 500 mb flow over the western U.S.

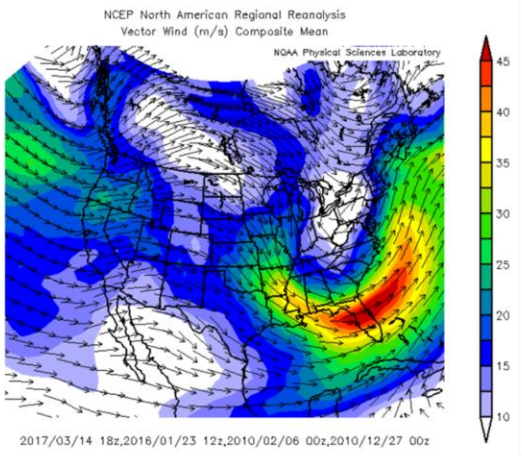
Geopotential height anomalies - 00z and 12z

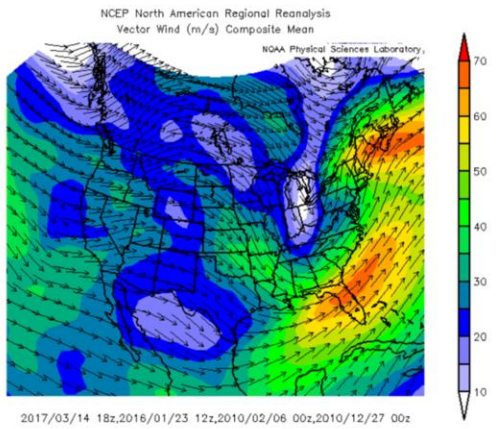




500 mb heights for this storm showed a pronounced 500 mb ridge over the western U.S., however the ridge was not anomalously strong.

500 mb and 250 mb composites from several high-impact right of track bias storms since 2010



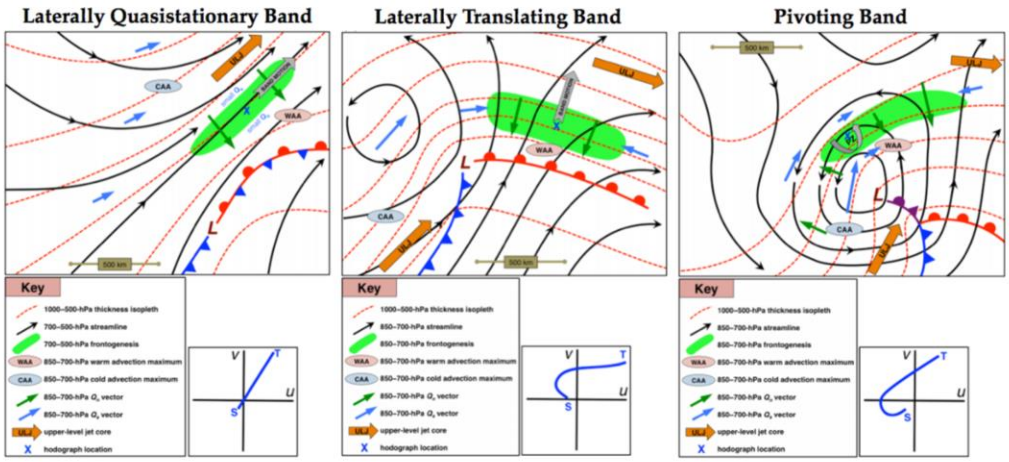


Composites of 500 mb and 250 mb heights for 4 storms during the past 10 years that exhibited this northward trend in guidance over the northern mid-Atlantic and southern New England regions likewise showed a pronounced western-U.S. ridge and appeared to be dominated by flow within the southern branch of the jet stream. Clearly, identification of these “northward trending” winter weather events is an area where more research is needed.

Summary

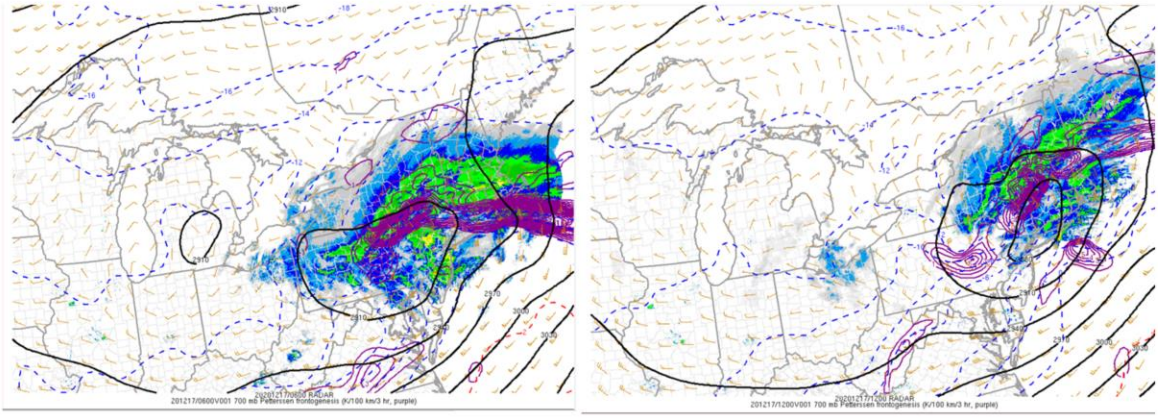
- Models exhibited a northward trend as the storm approached.
- The GFS in particular exhibited huge forecast errors for our area.
- High resolution models available at shorter lead times were better, but still too far south.
- All models exhibited bias of easterly 800-850 winds at OKX which observed soundings showed were actually southerly
- CSTAR research has identified a subset of cases where this north-western trend in the modeling is observed.
- These events tend to have extreme impact for our area, and more research is needed.

Conceptual models for heavy banded snowfall



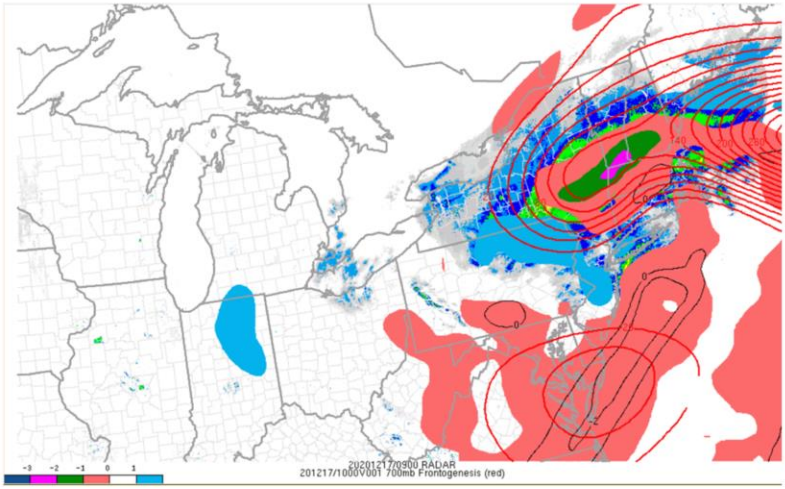
Research by Jaymes Kenyon has identified flow patterns associated with differing snow band motions. Confluent upper flow (left) is often associated with quasistationary bands. Laterally translating bands are often found in the eastern quadrant of cyclones, associated with strong warm air advection. Pivoting snow bands are often found in the northwest quadrant of cyclones. In this case, snow bands that developed appeared to transition from laterally translating, to pivoting, which is a common evolution.

700 mb frontogenesis, temperature and heights 06z and 12z



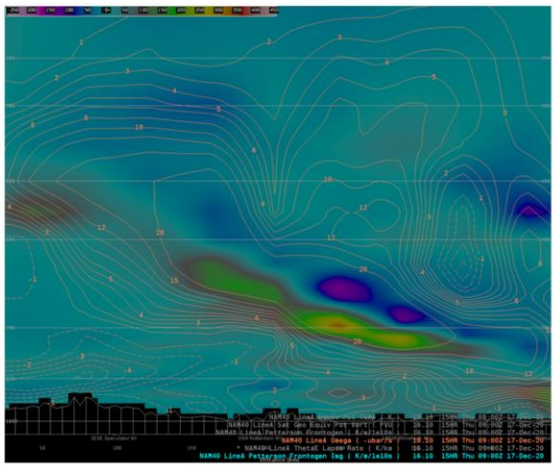
Heavy snow over eastern New York and western New England initially developed by 06z on the 17th, in right quadrant of the 700 mb cyclone and associated with strong frontogenesis (left). Eventually, a pivoting band can be seen in the left quadrant of the 700 mb cyclone as it shifts eastward toward the coastline.

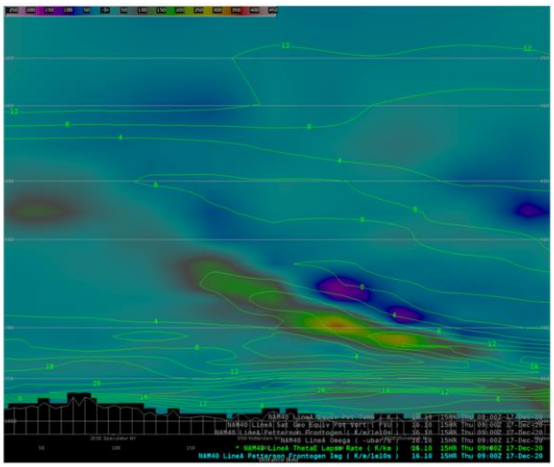
700 mb frontogenesis and 650-500 mb EPV at 10z



The heaviest snow was falling in the Capital District around 10 UTC on the 17th. At that time, a pronounced band of mid-level frontogenesis had become established across the area, with a layer of reduced stability above the front. The shaded area on this slide is associated with negative EVP in the layer from 650-500 mb, which is indicative of low static stability.

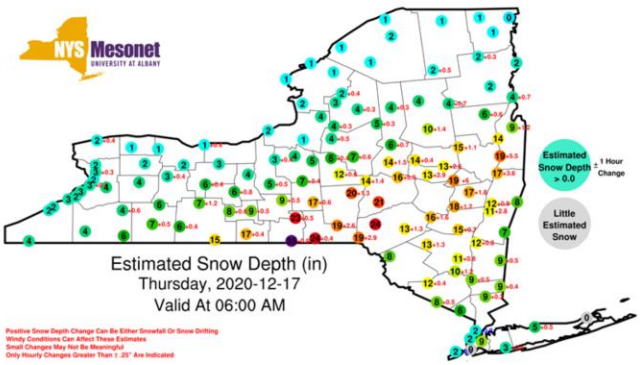
NAM forecast cross-sections valid 09z

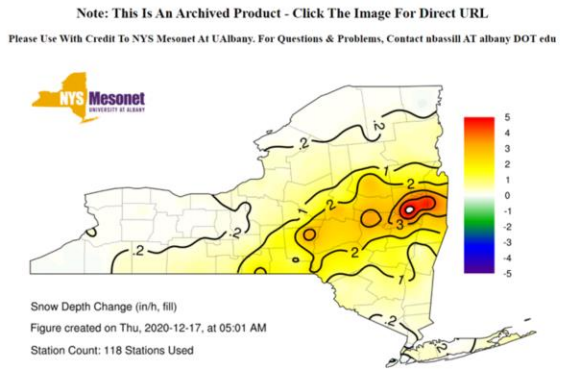




Cross-sections taken from south to north across the frontal zone in eastern New York show a sloping frontal zone, as indicated by the shaded frontogenesis on the slide. Strong upward vertical motion can be seen on the left slide in direct association with the frontogenesis. Reduced stability can be seen above the frontal zone on the right, as indicated by the contoured values of theta-e lapse rate.

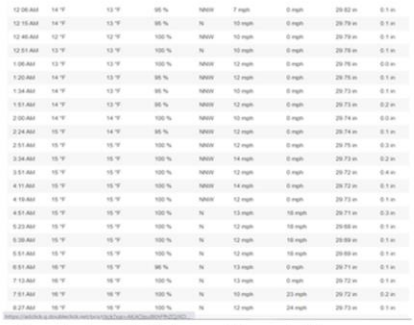
Meso-net snow depth change



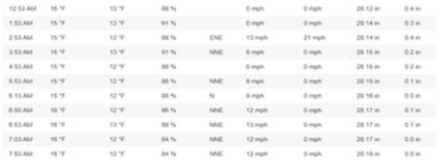


Once the snow with associated intense snow banding began, the bands were easily viewable via several New York State mesonet products, such as those on this slide.

ASOS Observations



Hourly decoded observations at Albany



Hourly decoded observations at Binghamton

3 inches per hour / 11 inches on the ground

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Observations for New York - NY
09Z 17 DEC 2020
METAR KALB 170851Z 33010KT 1/8SM R01/0700V1000FT +SN FZFG VV002 M09/M09 A3003 RMK AO2 TWR VIS 1/4 SLP172 SNINCR 3/11 P0036 60079 T10941094
SPECI KALB 170911Z 34012KT 1/4SM R01/1200V1600FT +SN FZFG VV002 M09/M09 A3003
SPECI KALB 170911Z 34012KT 1/4SM R01/1200V1600FT +SN FZFG VV002 M09/M09 A3003 RMK AO2 P0011 T10941094 $
SPECI KALB 170919Z 34010KT 1/4SM R01/1400V1600FT +SN FZFG VV003 M09/M09 A3004
SPECI KALB 170919Z 34010KT 1/4SM R01/1400V1600FT +SN FZFG VV003 M09/M09 A3004 RMK AO2 PRESRR P0014 T10941094 $
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METAR KBGM 170553Z AUTO 1/4SM +SN FZFG VV002 M09/M11 A2985 RMK AO2 TWR VIS 3/4 SLP136 P0040 60120 T10891106 11072 21089 58023 RVRNO
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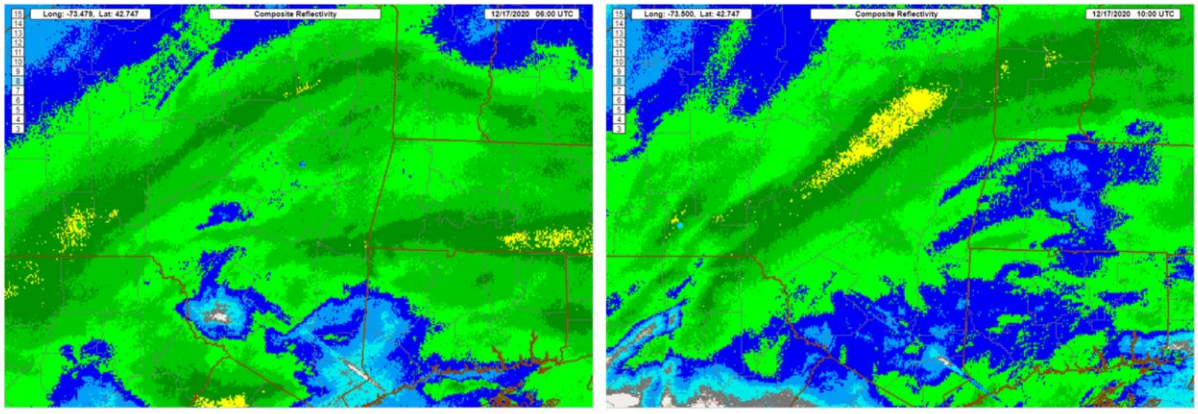
0.40 inches liquid in 1 hour

Coded observations at Albany and Binghamton

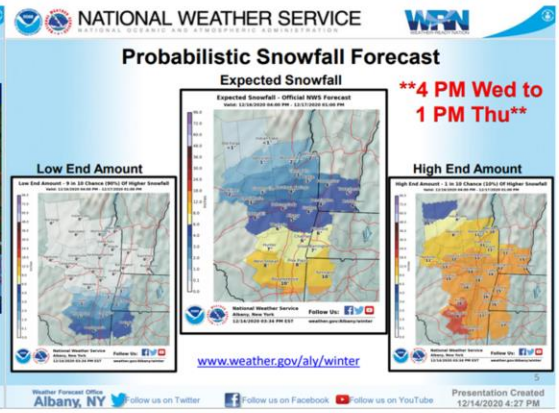
Some very impressive observations were also available on the ASOS network. For example, observations at the ALB observation site at 09z indicated a snow depth increase of 3 inches in an hour with a one hour liquid equivalent precipitation of 0.36 inches. At Binghamton, a 0.40 inch liquid equivalent was observed in one hour at 06z.

Radar 06z and 10z



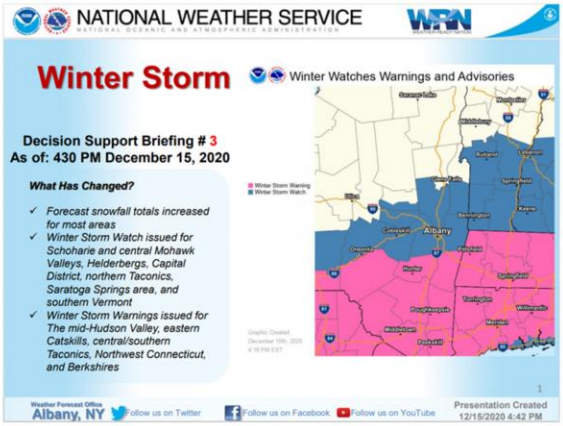
A very intense snow band initially set up along and just north of I-88 from near Binghamton, to north of Albany at 06z. Additional snow bands advanced from the south, and ultimately a very intense band was established just north and west of Albany at 10z. This band pivoted across the Capital District and west central New England during the morning on the 17th.

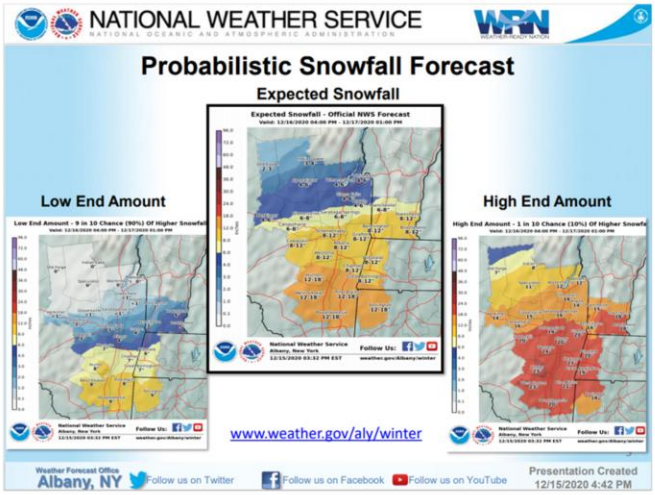
WFO ALY Forecasts - December 14th



Forecasts issued by WFO Albany are summarized on the next few slides. A winter storm watch was initially issued for the mid-Hudson Valley on December 14th. Heavy snowfall was forecast for the mid-Hudson Valley. Much less snow was expected as most likely for the Capital District, however a high-end amount of over a foot at Albany indicated that there was considerable uncertainty in the forecast.

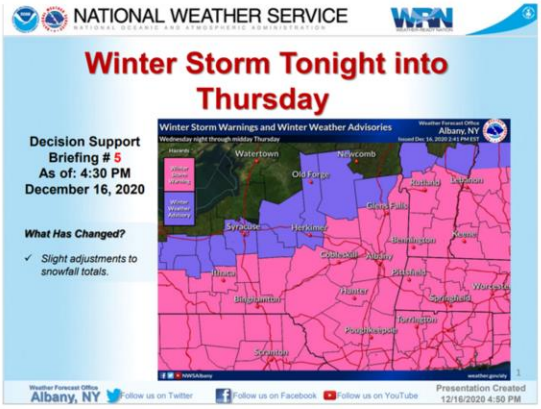
WFO ALY Forecasts - December 15

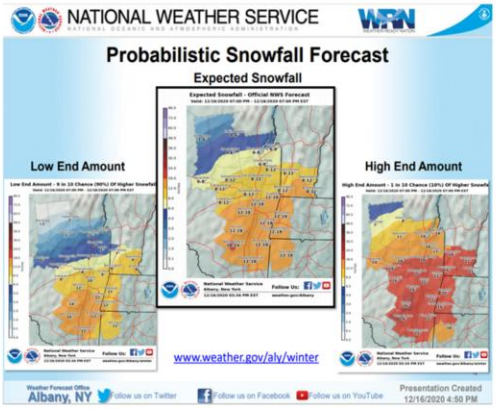




A winter storm watch was expanded northward to cover the Capital District on the 15th, while warnings were issued for the Catskills, mid-Hudson Valley, Berkshires and northwest Connecticut. Snowfall forecasts were adjusted accordingly, with areas of expected heavy snowfall shifting northward.

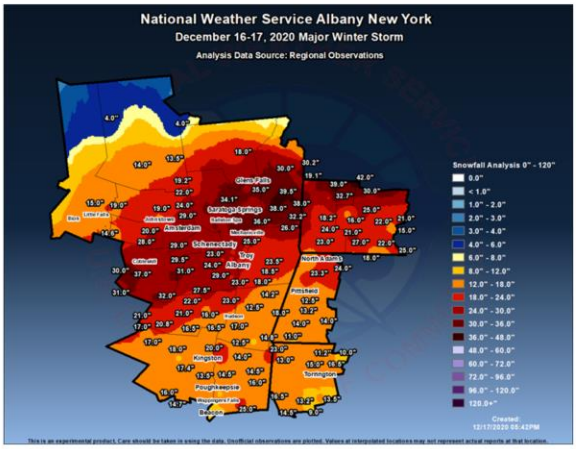
WFO ALY Forecasts - December 16

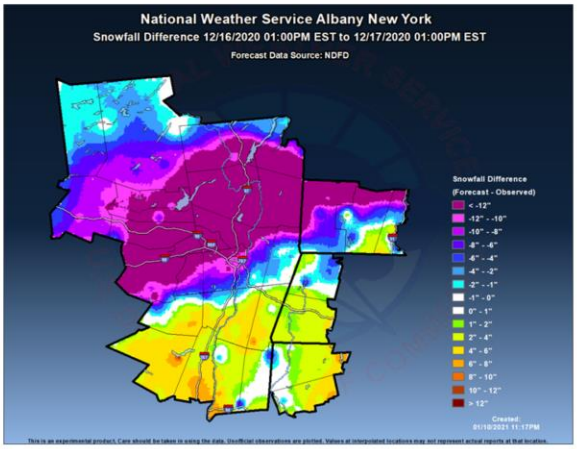




On the 16th, warnings had been adjusted northward to cover the area from Saratoga county southward. Watches were extended to the southern Adirondacks. Heavy snowfall was no being forecast for most of the area, with high amounts of 2 feet for the Castkills and mid-Hudson Valley.

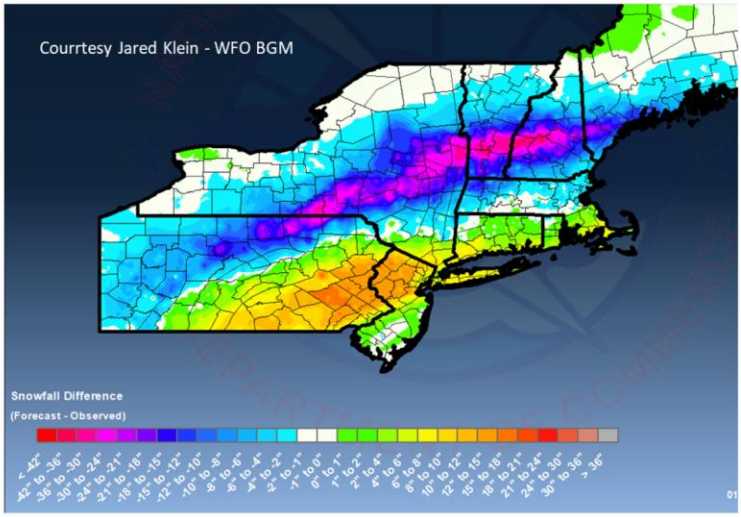
Observed snowfall and forecast error





Observed snowfall from this event indicated that a band of 2 to 3 feet of snow occurred from the northern Catskills, to Saratoga county and into southern and central Vermont. Slightly lower amounts were observed north and south of the band, with snowfall totals of over a foot observed for all by the Adirondacks. Snowfall forecasts were too low for most of the area. The largest snowfall forecast errors, greater than a foot, occurred within the band of heaviest snow, while forecasts were quite accurate over the far northern and southern parts of the forecast area.

NWS errors through the northeast



A look at snowfall forecast error for a larger area over the northeast indicated that snowfall was underforecast within the band from northern Pennsylvania to central New England, and overforecast over southeast Pennsylvania and northern New Jersey.

Science Questions / Comments

- Can we anticipate north-westward trends in model forecasts?
- When should lower-resolution operational models (GFS) be completely abandoned?
- What are the implications for the National Blend of Models?
- Banding was clearly anticipated. But 5 inches of snow per hour was not. Could this be anticipated?
- Snow-to-liquid ratios were maximized within the band but did not appear to be extreme. What was extreme was 0.40 inches of liquid per hour!

References

National Blend of Models - https://www.weather.gov/mdl/nbm_home

Model Data - https://www.tropicaltidbits.com/

High resolution ensemble forecasts (HREF) - https://www.spc.noaa.gov/exper/href/

CSTAR research on track biases - https://vlab.ncep.noaa.gov/web/albany-cstar/track-and-intensity-errors-of-northeast-cyclones

CSTAR research on snow band motion - https://vlab.ncep.noaa.gov/web/albany-cstar/the-motion-of-mesoscale-snowbands-in-northeast-winter-storms

Storm Prediction Center Mesoanalysis Page - https://www.spc.noaa.gov/exper/mesoanalysis/

New York Mesonet - http://www.nysmesonet.org/