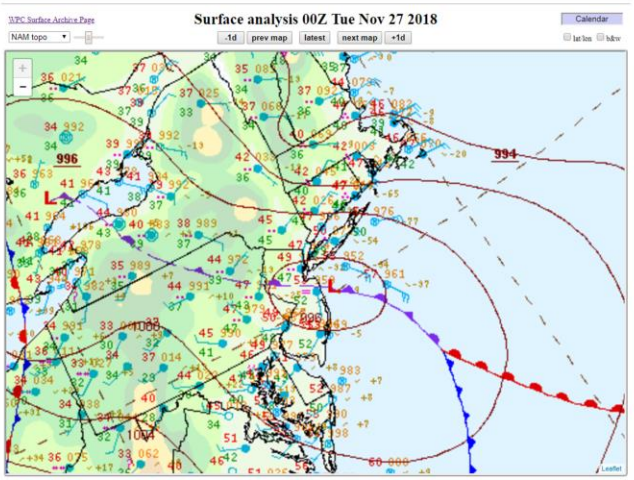
The November 26-27 Elevation Snowstorm

Mike Evans
WFO Albany

Outline

- Large-scale forcing
- Meso-scale forcing
- Soundings
- High resolution models
- Observations
- Upslope event
- Summary / Conclusion

Surface analysis – 00z November 27



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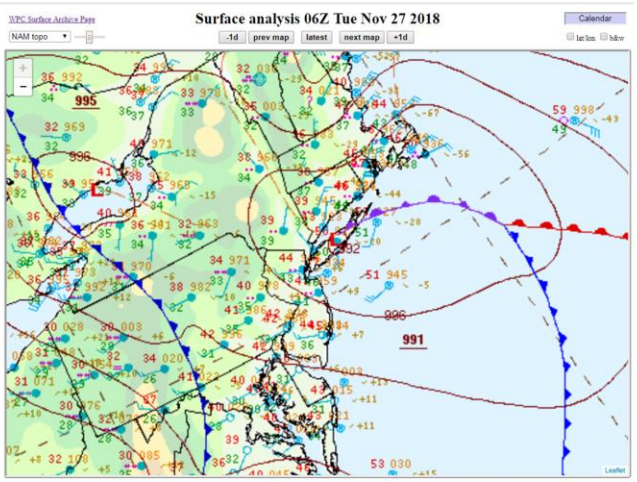
A surface cyclone moving north along the mid-Atlantic coast spread precipitation across eastern New York and western New England during the evening on the 26th.

Surface analysis - 06z November 27



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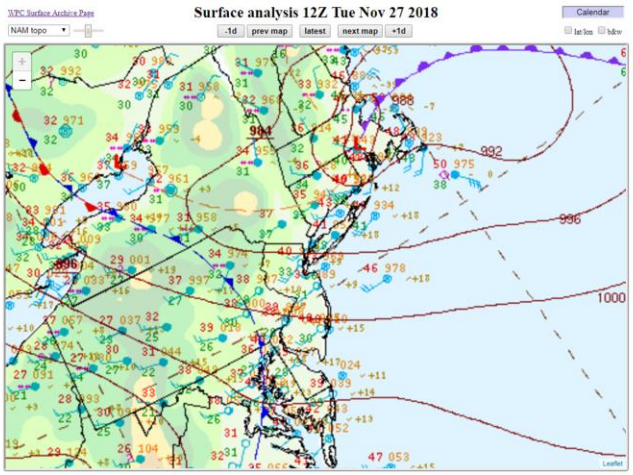
The surface low pressure center tracked from just east of the New Jersey coast to central Long Island during the evening.

Surface analysis – 12z November 27



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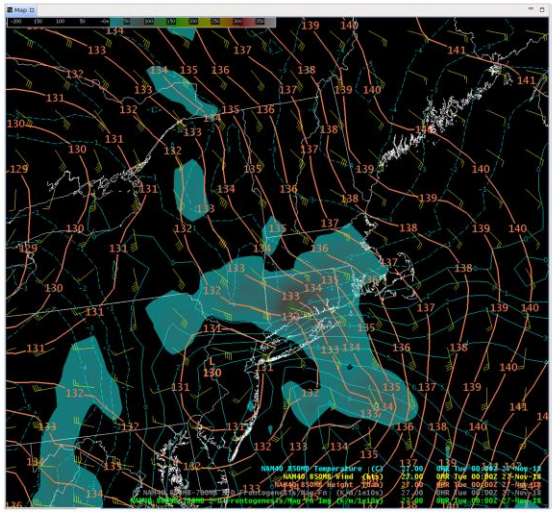
By daybreak on the 27th, the surface low was centered over southeastern New England.

850 mb – 00z November 27



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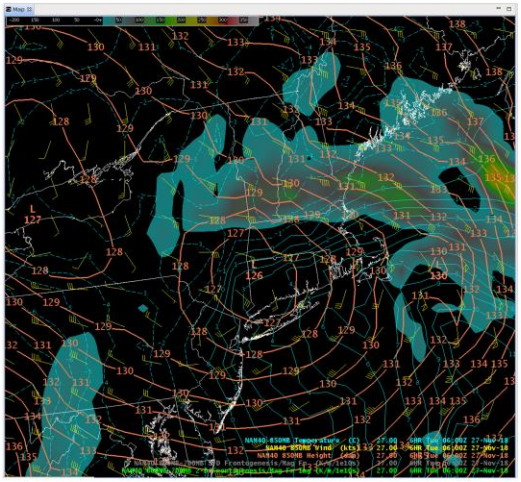
The 850 mb low tracked across New Jersey during the evening on the 26th. The frontal zone and associated frontogenesis was maximized over southern New England at 00z on the 27th. A 50 kt southeasterly flow can be seen on this slide over-running the low-level frontal zone near the southern New England coastline.

850 mb – 06z November 27



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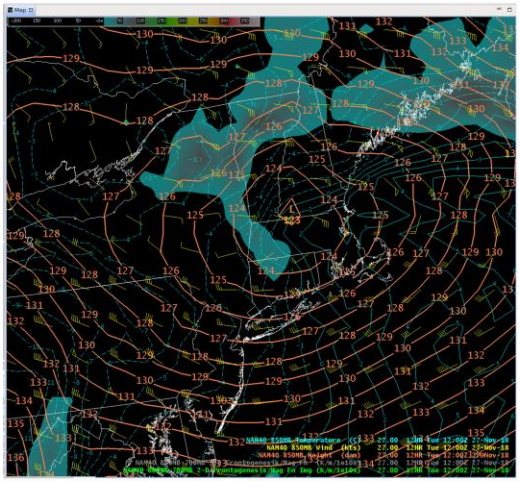
The zone of frontogenesis lifted north across central New England by early morning on the 27th, associated with a 40 to 50 kt easterly flow at 850 mb over-running the frontal zone.

850 mb – 12z November 27



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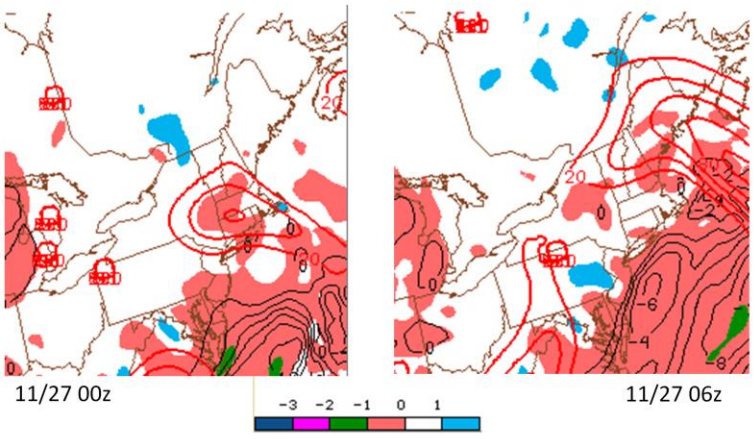
The frontogenesis lifted into northern and western New England by 12z on the 27th, as low pressure tracked northeast toward Maine.

700 mb frontogenesis and 650-500 mb EPV



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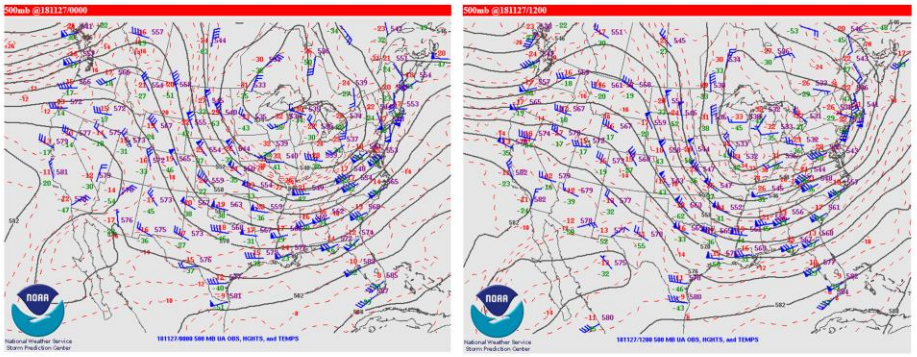
This slide from the SPC meso-analysis shows a zone of 700 mb frontogenesis lifting northeast from southern New England to northern New England early on the 27th. The shaded areas indicate areas of slightly negative equivalent potential vorticity (EPV) from 650-500 mb, The justaposition of the frontogenesis and slightly negative EPV indicated the potential for banding of heavy precipitation during the period.

500 mb analysis



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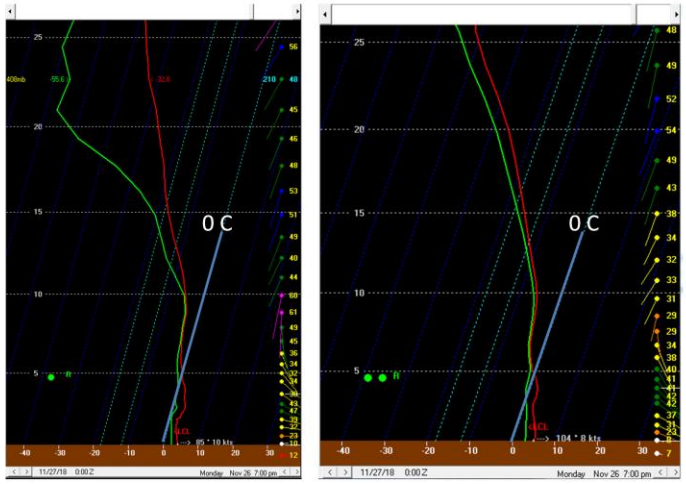
At 500 mb, a broad upper low tracked across the western and central Great Lakes. A short-wave trough rotated up the east coast around the eastern side of the upper low.

12z NAM (left), GFS (right) valid 00z November 27 at Albany



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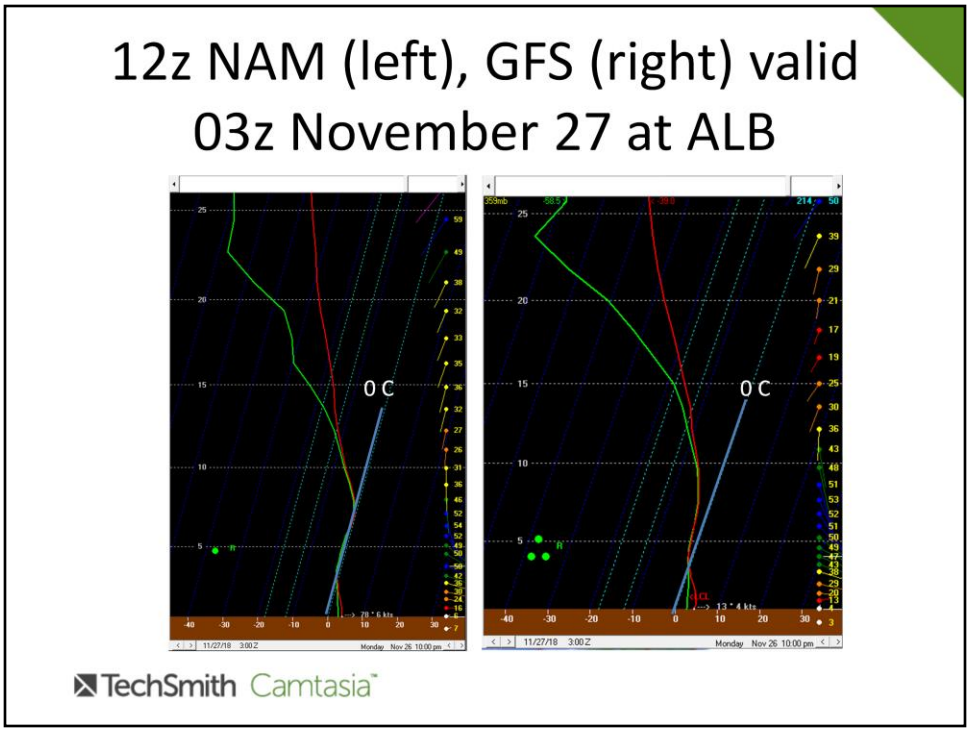
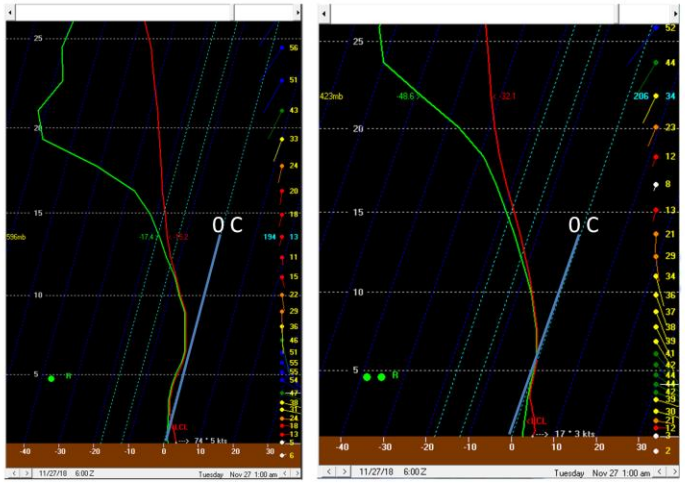
NAM and GFS forecast soundings valid at Albany at 00z on the 27th indicated a warm layer below 5000 feet. Other features of note include the 40 knot low-level easterly flow. These soundings were warm enough to support rain at Albany, as snow would melt as it fell through the boundary layer. The soundings are quite similar below 10000 feet, although the NAM shows more dry air above 10000 feet.



At 03z, some typical differences between the NAM and GFS are beginning to show up in the soundings valid at Albany. The GFS sounding is slightly dryer in the boundary layer, and the NAM is slightly warmer above 3000 feet. The wind profiles are rather similar. Once again, these soundings are supportive of rain in the Hudson valley, as snow would melt while falling through the boundary layer. However, temperatures below freezing above about 2500 feet ASL would indicate that higher elevations could experience snow around this time.

12z NAM (left), GFS (right) valid 06z November 27 at Albany



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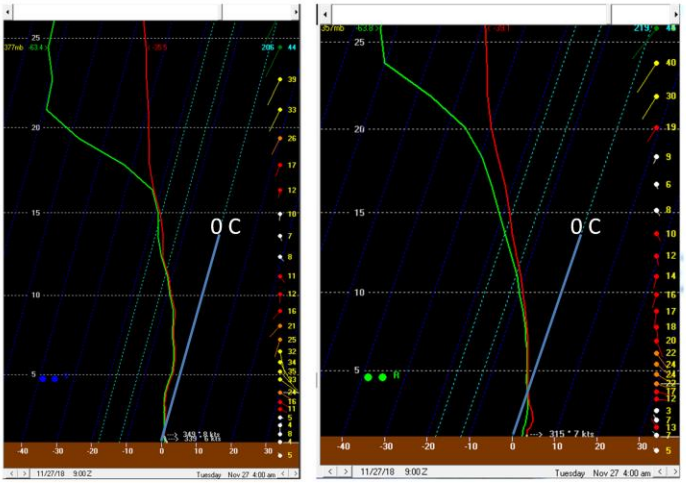
At 06z, the soundings are gradually cooling. The GFS sounding is a bit warmer than the NAM below 5000 feet, while the NAM is slightly warmer in association with a weak inversion around 6000 feet. The boundary layer still appears to be warm enough to support rain in the Hudson valley, while the NAM in particular appears to be cold enough for higher-elevation snow above 2000 feet.

12z NAM (left), GFS (right) valid 09z November 27 at Albany



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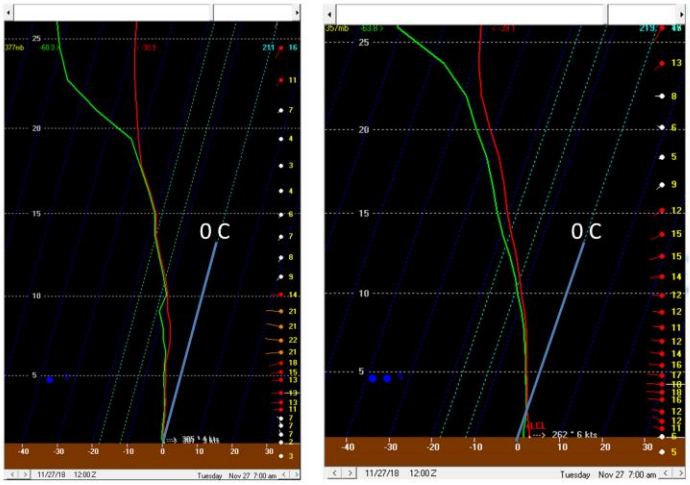
At 09z, typical differences between the NAM and GFS are quite evident. The GFS is warmer and dryer than the NAM in the boundary layer. The NAM is forecasting a weak inversion centered near 5000 feet ASL, while no such inversion can be seen on the GFS sounding. The NAM is now cold enough in the boundary layer to support snow at Albany, while the boundary layer remains too warm for snow on the GFS.

12z NAM(left), GFS (right) valid at 12z November 27 at Albany



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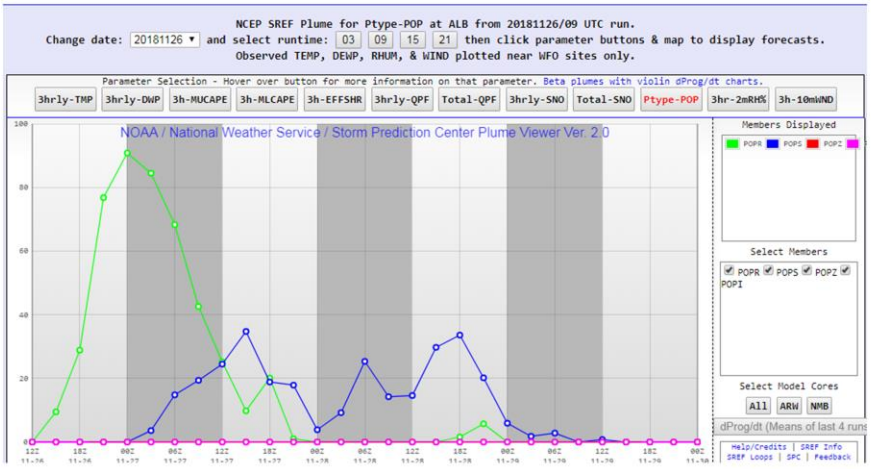
At 12z, the GFS has cooled the boundary layer enough for snow even in the Hudson Valley. The differences between the NAM and GFS are not as pronounced at 12z, compared to some earlier times.

Probability precipitation from the 11/26 09z SREF valid at Albany



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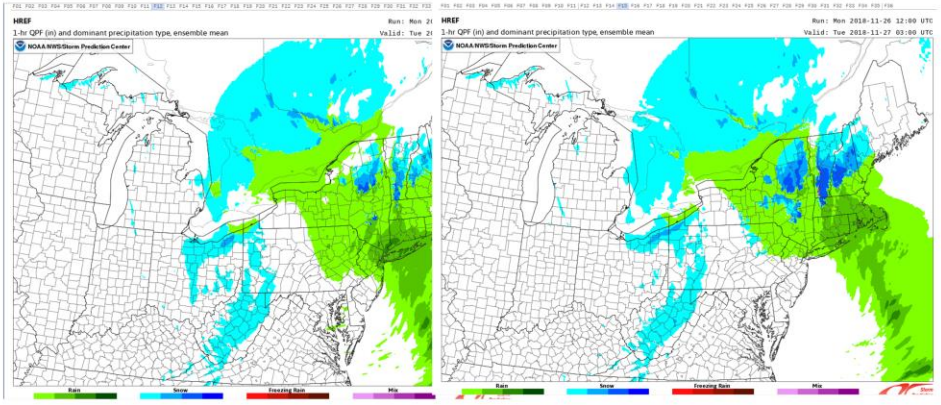
The graph on this slide, showing precipitation-type forecasts from the 09z November 26th run of the SREF, indicated high probabilities for rain at Albany through 06z on the 27th, followed by a lower chance of snow centered just after 12z.

12z HREF p-type – 00z, 03z



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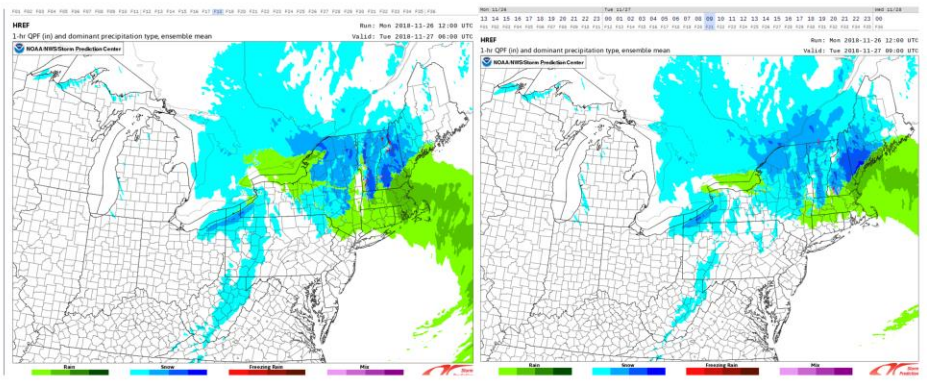
Precipitation-type forecasts from the HREF high resolution ensemble indicated increasing coverage of snow at higher elevations as the evening progressed on the 26th.

12z HREF p-type – 06z, 09z



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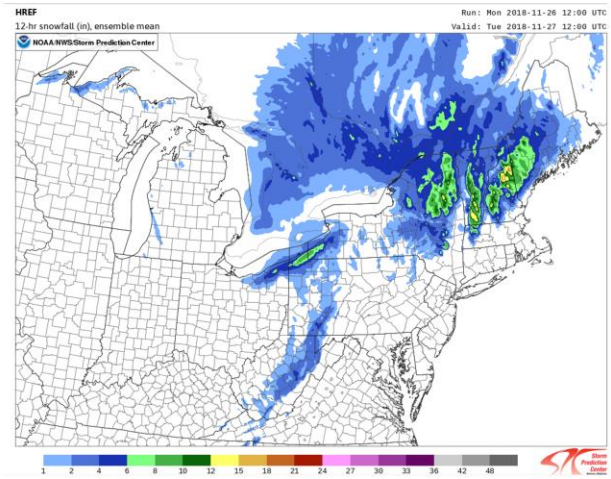
At 09z, the HREF forecast indicated mainly snow over eastern New York, with heavier snow continuing over higher elevations. Rain was persisting over much of Massachusetts and northern Connecticut, except for the higher terrain in the northern Berkshires.

HREF mean snowfall through 11/27 12z



The snowfall forecast from the HREF indicated totals over a foot for portions of the southern Green Mountains and also isolated locations in the southern Adirondacks. Most of the higher elevations outside of the Hudson and Mohawk Valleys were forecast to receive from 6 to 10 inches. Lower elevations were forecast to receive less than 2 inches.

Froude Numbers

From: Muccilli, 2015.

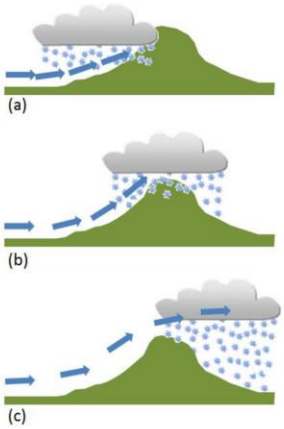


Figure 6. Blocked flow as seen on the top (a), contrasted with near critical flow in the middle (b), and unblocked flow on the bottom (c).

Froude Numbers (wind speed / stability and barrier height) can be used to evaluate the impact of terrain on precipitation patterns. Light wind, high stability and tall barriers promote blocked flow.

Values less than 1 indicate blocked flow (a).

Values from 1 to 2 indicate near critical flow (b).

Values greater than 2 indicate unblocked flow (c).

Based on 12z 11/26 NAM forecasts, layer from 0-1 km, barrier 500 m high:

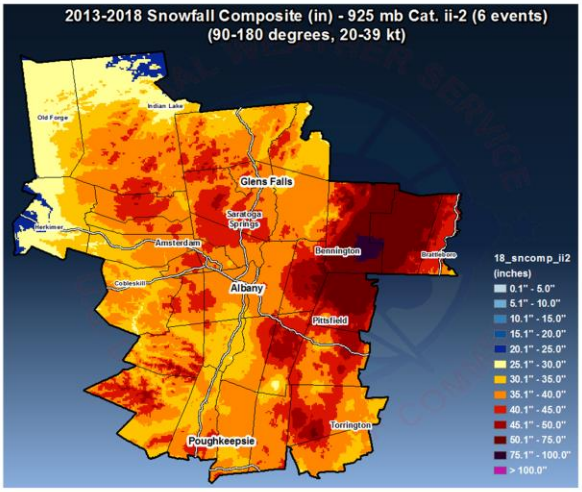
Froude at 21z at ALB = 1.8
Froude at 00z at ALB = 1.9
Froude at 03z at ALB = 2.1
Froude at 06z at ALB = 1.9

TIME-AVERAGED FROUDE NUMBER = 1.9

FAVORED PRECIPITATION MAXIMA NEAR OR JUST DOWNSTREAM FROM THE TOP TERRAIN BARRIER.

This slide describes how evaluation of the stability, wind flow and topography could help forecasters to evaluate how topography could have impacted precipitation amounts during this event. The Froude number, which is a function of wind, stability and topography was indicative of an event where heaviest precipitation amounts would be location over and perhaps just downstream from terrain barriers, with lighter amounts upstream from the barriers. In eastern New York and western New England, a good example of a terrain barrier perpendicular to easterly flow would be the Green Mountains, Berkshires and Taconics, which are all oriented roughly from south to north.

Composite: snowfall with 925 mb flow from east-south



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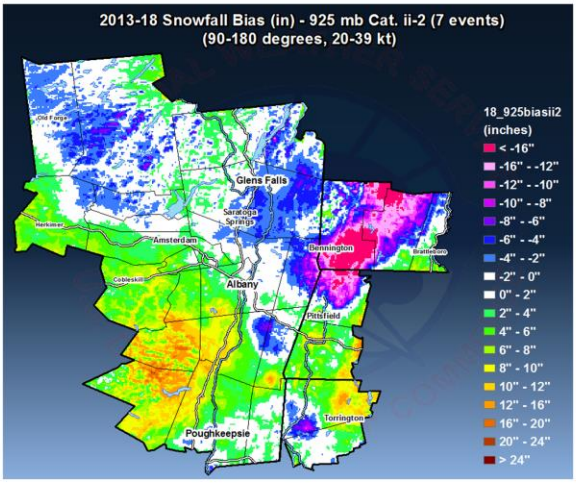
The event early on November 27th was associated with a strong easterly low-level flow. This slide shows a composite of snowfall in eastern New York and western New England for many cases associated with significant easterly flow. Note that the heaviest snowfall amounts tend to occur over the southern Green Mountains in Vermont in these cases.

Composite: forecast bias with 925 mb flow from east-south



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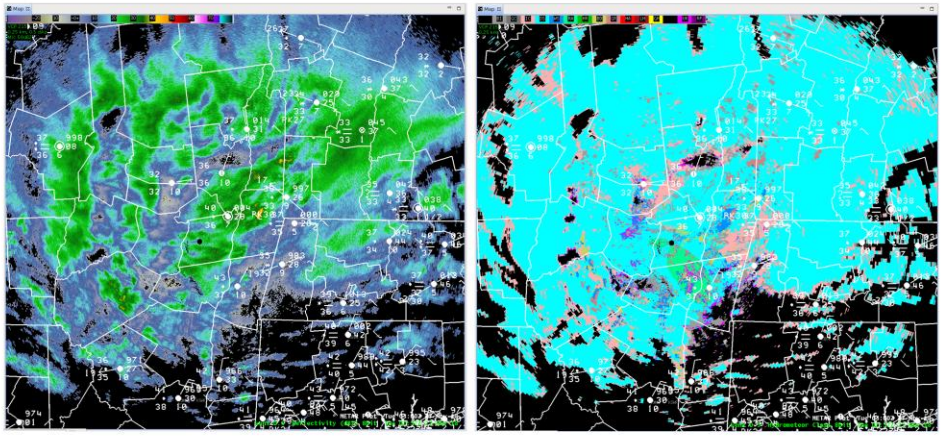
The composite on this slide indicates that snowfall forecasts are often too low over the southern Green Mountains in east-southeasterly flow cases.

Radar reflectivity (left) and hydrometer classification – 03z



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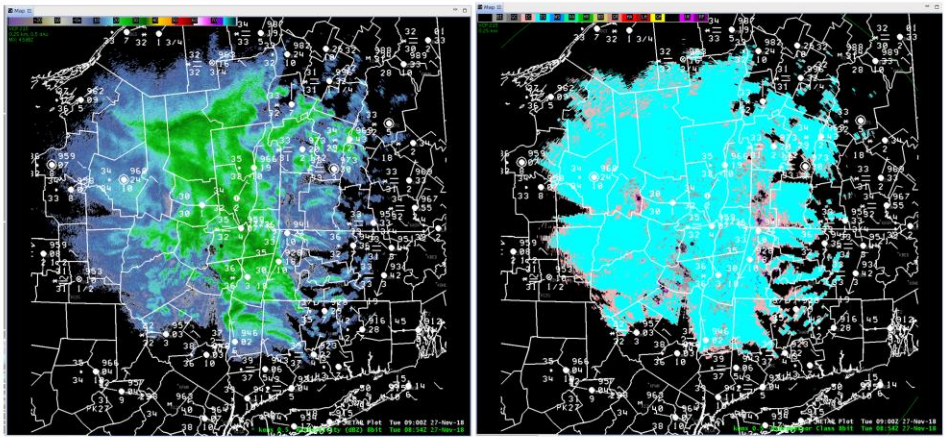
Radar reflectivity at 03z on the 27th indicated widespread precipitation occurring across the area, with bands of enhanced precipitation. The dual pol-based hydrometeor classification scheme indicated mainly snow across the area at 03z, despite observations indicating rain in the Hudson Valley. In this case the radar, which is located at nearly 1500 ASL on higher terrain south of Albany, was likely sampling primarily snow, as it overshot the melting layer occurring below the beam. Therefore, the algorithm was of limited use for determining precipitation type at lower elevations.

Radar reflectivity (left) and hydrometeor classification – 09z



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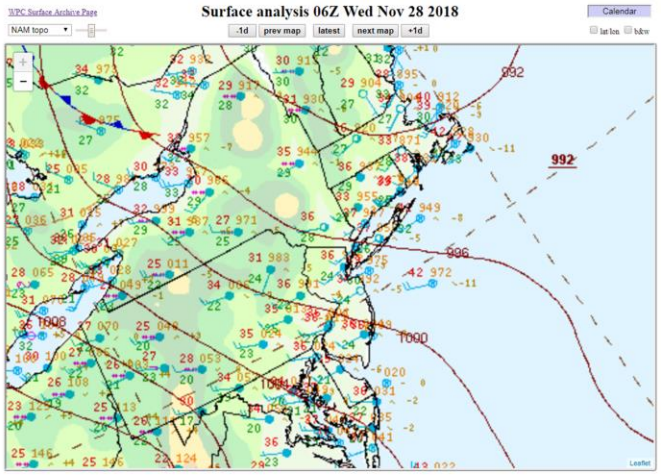
At 09z, widespread precipitation was continuing across the area. Precipitation was changing to snow at lower elevations.

Surface analysis – 11/28 06z



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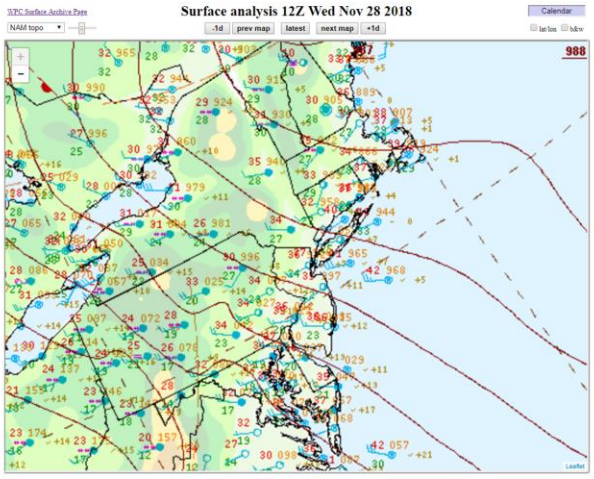
Cyclonic northwesterly flow was persistent in the wake of the storm late on the 27th into the 28th.

Surface analysis 11/28 12z



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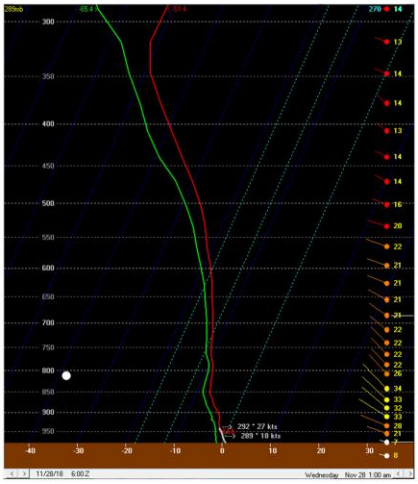
This flow pattern would result in persistent snows for west-northwest facing slopes across much of the northeast U.S.

00z 11/28 NAM sounding valid at Albany at 06z 11/28



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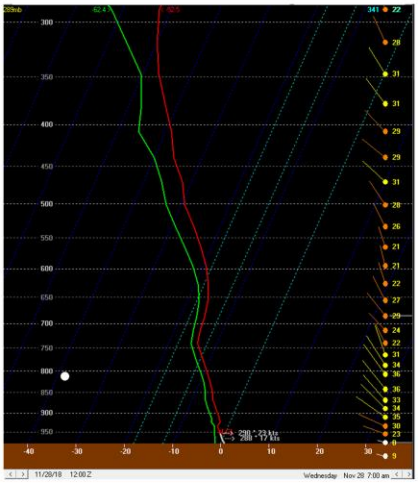
This NAM sounding valid at Albany at 06z on the 28th indicated northwesterly flow with a deep moist layer extending into the dendritic snow growth layer with temperatures from -10 to -20 C.

00z NAM sounding valid at Albany at 12z 11/28



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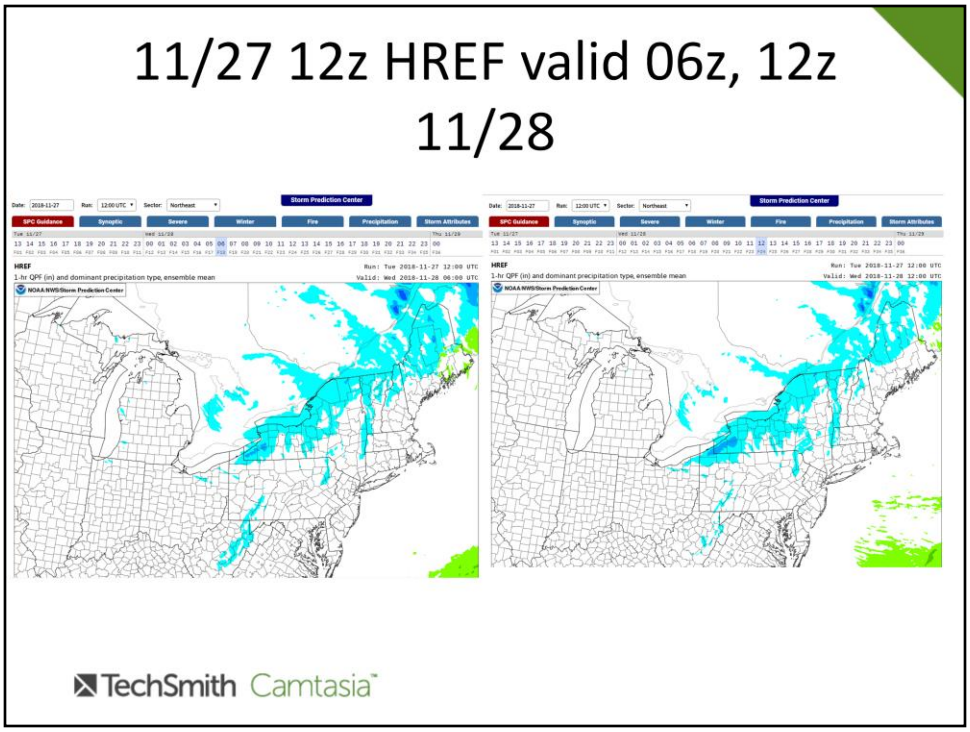
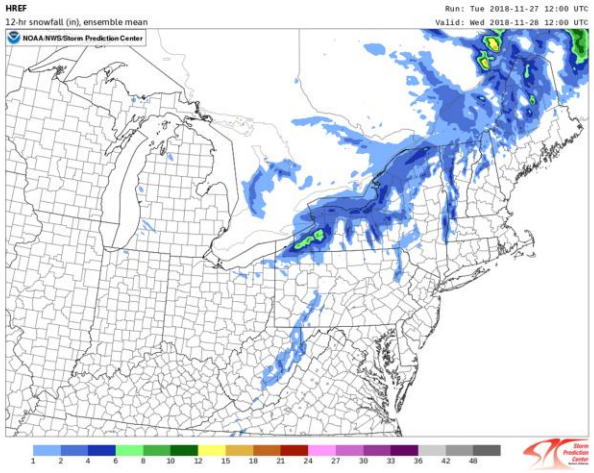
The flow pattern persisted for several hours into the day on the 28th.



The HREF high resolution ensemble forecast a persistent band of light snow extending from the west slopes of Green mountains south to the west slopes of the Taconics into the 28th.

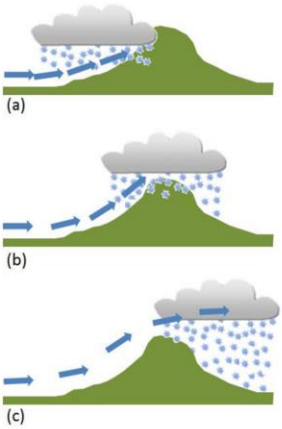
HREF forecast 12 hour snowfall valid 11/28 12z



Snowfall forecasts for that area ranged from 1 to 6 inches.

Froude Numbers

From: Muccilli, 2015.



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Values from 1 to 2 indicate near critical flow (b).

Values greater than 2 indicate unblocked flow (c).

Based on 12z 11/26 NAM forecasts, layer from 0-1 km, barrier 500 m high:

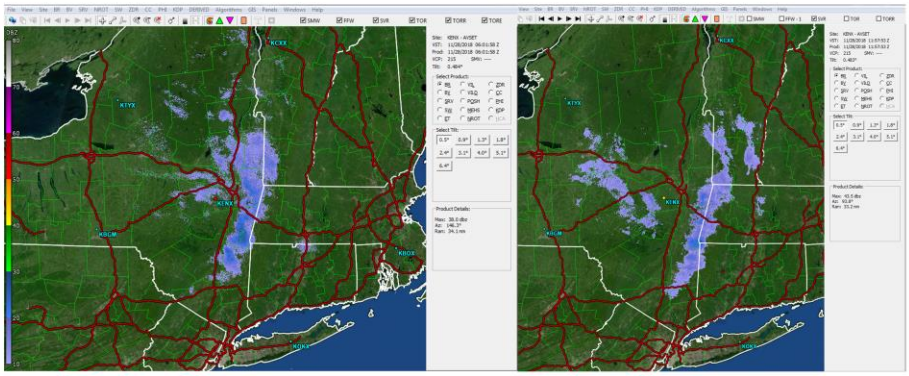
Froude at 06z at ALB = 2.0
Froude at 12z at ALB = 2.2

TIME-AVERAGED FROUDE NUMBER = 2.1

FAVORED PRECIPITATION MAXIMA NEAR OR JUST DOWNSTREAM FROM THE TOP TERRAIN BARRIER.

Once again, Froude number calculations indicated that the heaviest precipitation should have fallen near the top of topographic barriers perpendicular to the west-northwest flow.

Radar reflectivity – 06z, 12z 11/28



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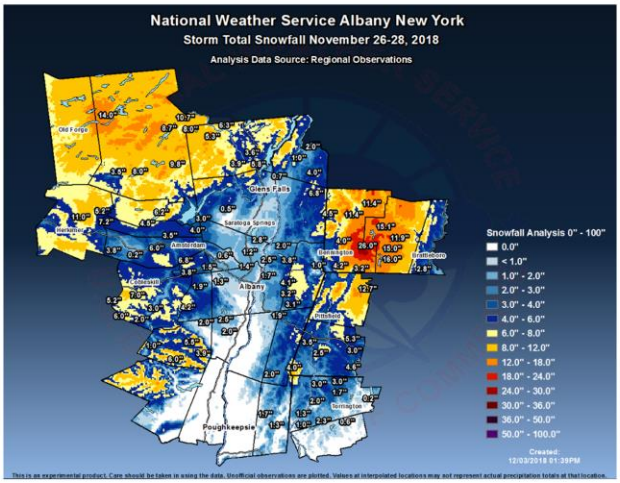
Radar reflectivity indicated a persistent band of snow east of the Hudson Valley through the morning hours on the 28th.

Total observed snowfall



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Total snowfall for the entire event is shown on this slide. The heaviest snows fell in the Green Mountains of southern Vermont, where localized amounts over 2 feet were reported. 6 to 12 inches of snow generally fell across the southern Adirondacks and northern Berkshires, with up to 6 inches falling in the Catskills. 3 to 6 inches fell over higher terrain east of the Hudson Valley, including the Rensselear plateau, located on the west slopes of the Taconics east of Albany. Snow fall totals in the Hudson Valley were generally less than 2 inches.

Conclusion / Summary

- A two-phased storm system brought heavy snowfall to higher elevations in eastern New York and western New England on November 27-28.
- Differences in snowfall due to elevation were particularly noteworthy for this storm, with totals ranging from 2 feet in the Green Mountains of southern Vermont, to less than 2 inches in the Hudson Valley.
- The first phase was associated with a coastal storm which produced heavy snow in Green Mountains and southern Adirondacks, with rain changing to a light snowfall over the Hudson Valley.
- High resolution models, ensembles and model forecast soundings were useful tools to predict precipitation-type, as well as a change from rain to snow at lower elevations.
- Froude number calculations indicated that the heaviest precipitation with this event would focus particularly over higher terrain.
- The second phase was northwesterly flow upslope which brought several more inches of snow to west-northwest-facing slopes.