Assessment of Crystal Characteristics and Snowfall Impact During the North Carolina Snowstorm of 17 January 2018

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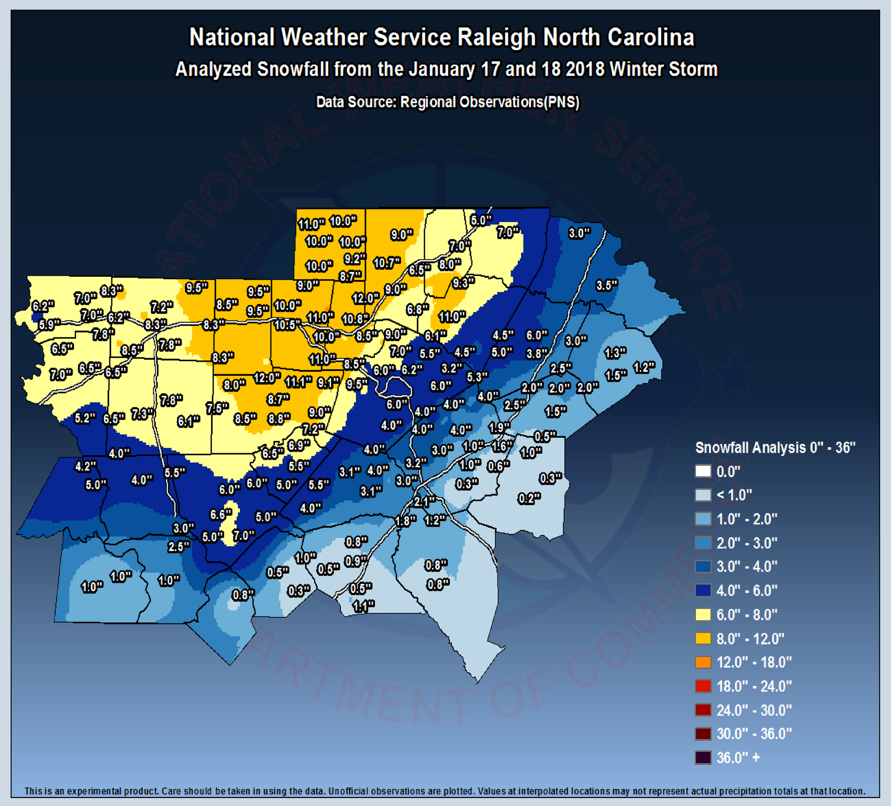
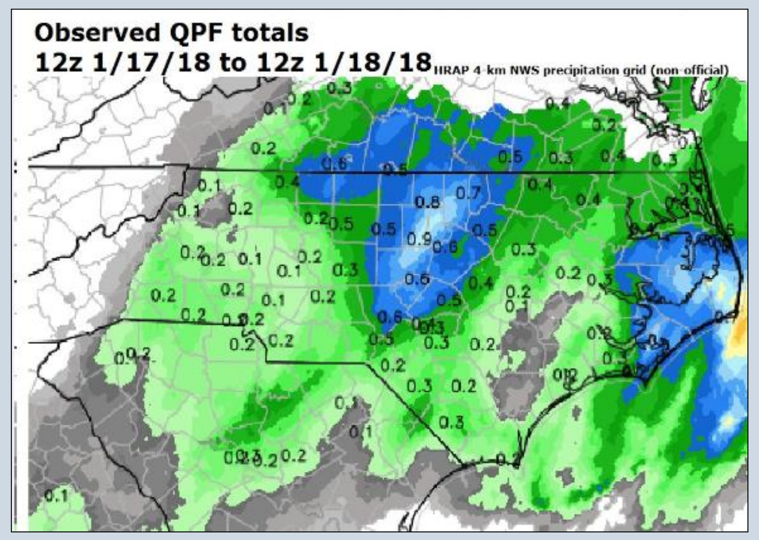
***Overview**: On 17 January 2019 a slow-moving but vigorous mid and upper-level trough produced large height falls, strong frontogenetic forcing, and divergence aloft over North Carolina, in conjunction with the arrival of deep cold air. Forecasters were confident that precipitation would start as a brief rain-snow mix, before quickly changing to all snow. Predictions of precipitation type, liquid-equivalent precipitation amounts, and snow-liquid ratio (SLR) were fairly accurate; however, impacts were greater than anticipated. While the heavy snowfall totals and subsequent travel difficulties were expected, the accumulation of heavy, wet snow on trees and power lines was greater than expected, producing widespread power outages, an impact more often associated with ice storms in this region.*

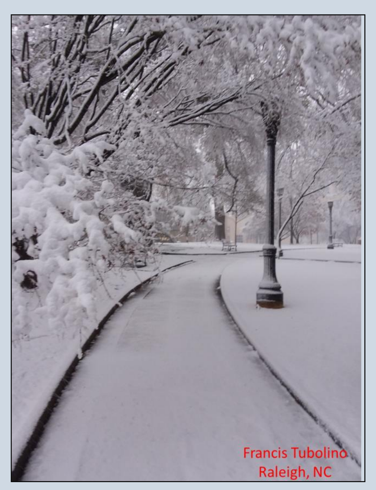
***The questions at hand**: What factors may have contributed to the atypical heavy snow accumulation on trees and power lines in this event? And, how can we better anticipate this impact in future such storms?*

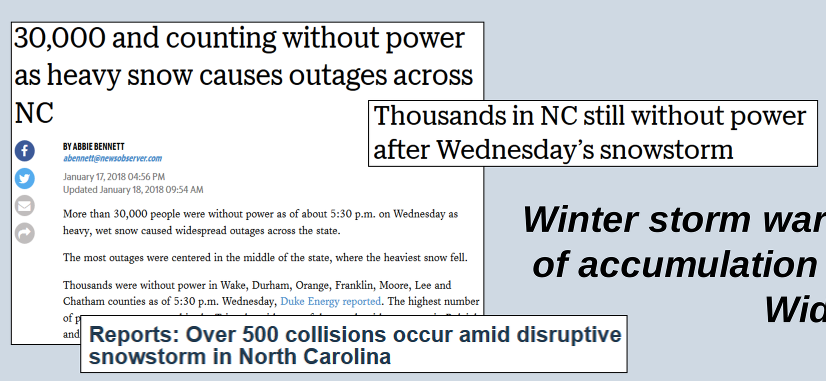


As much as a foot of snow fell on the N Piedmont of NC. Everyone across the forecast area saw snow, but a longer duration of near-freezing wet bulb temperatures and warmer surface temperatures in the east allowed for a longer period of rain-snow mix, reducing accumulations there.



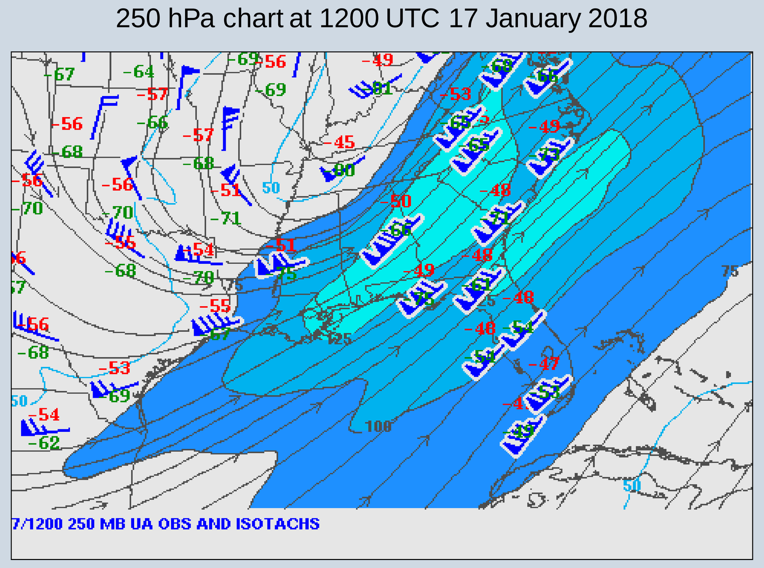
Snow-liquid ratios (SLRs) varied across the area, but they were roughly 12-15:1 within the heaviest snow areas, a bit higher than climatology.



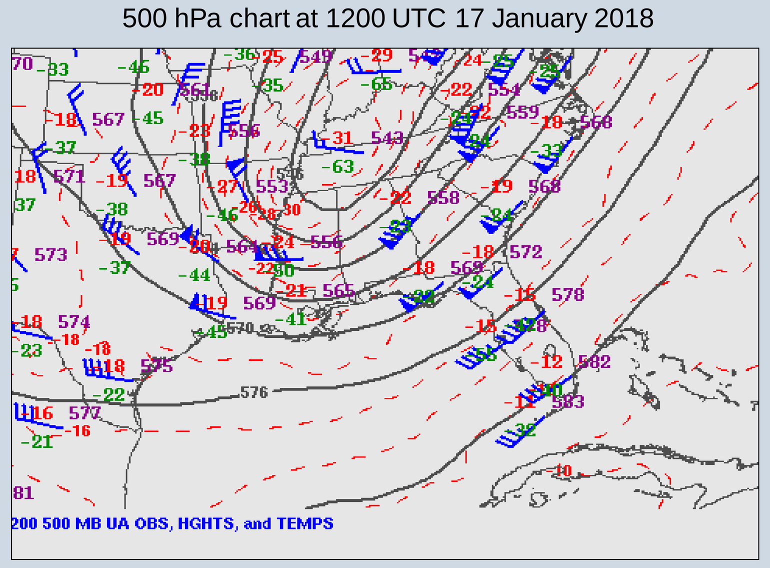


Winter storm warnings were in effect for the area, but the extent of accumulation on trees and power lines was underestimated. Widespread power outages resulted.

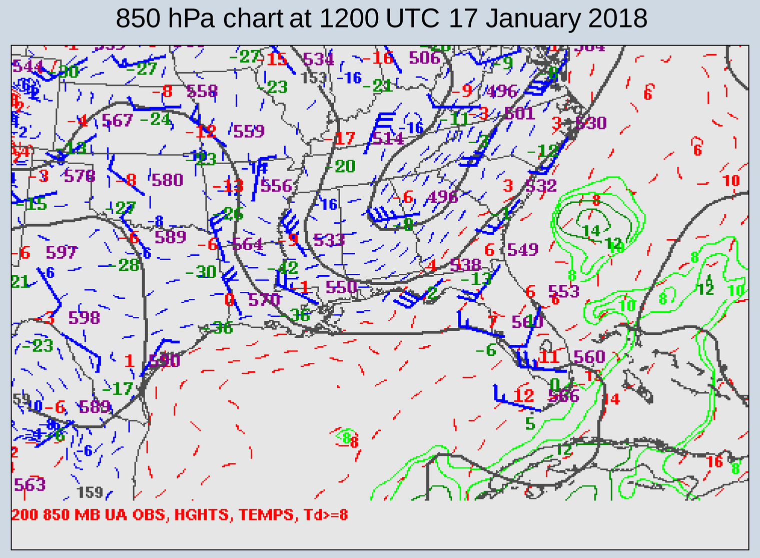
250 hPa chart at 1200 UTC 17 January 2018



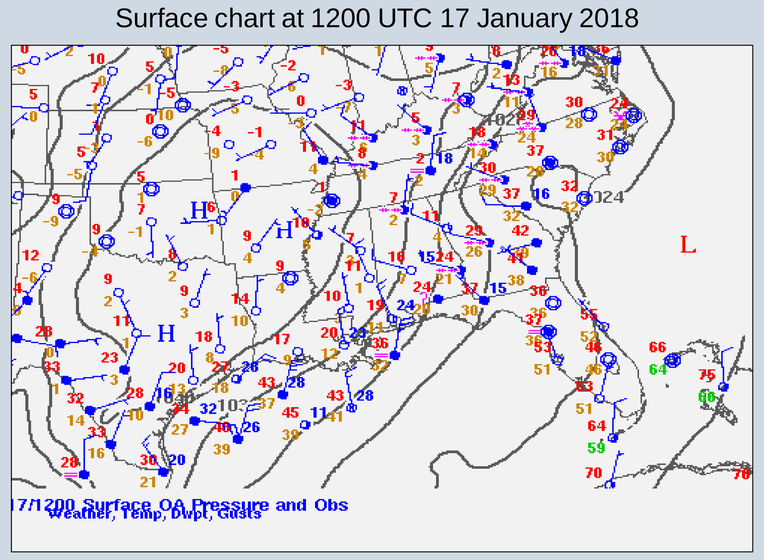
500 hPa chart at 1200 UTC 17 January 2018



850 hPa chart at 1200 UTC 17 January 2018

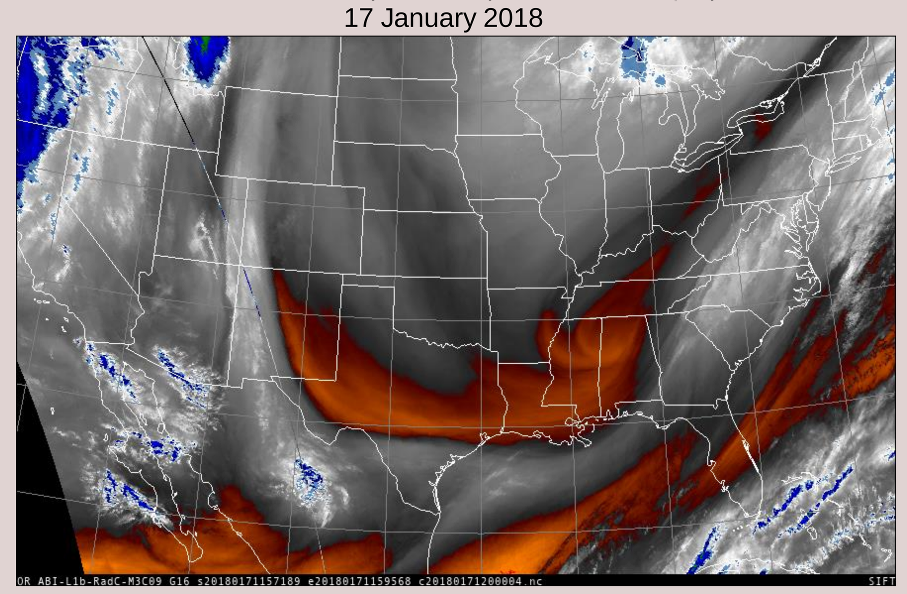


Surface chart at 1200 UTC 17 January 2018

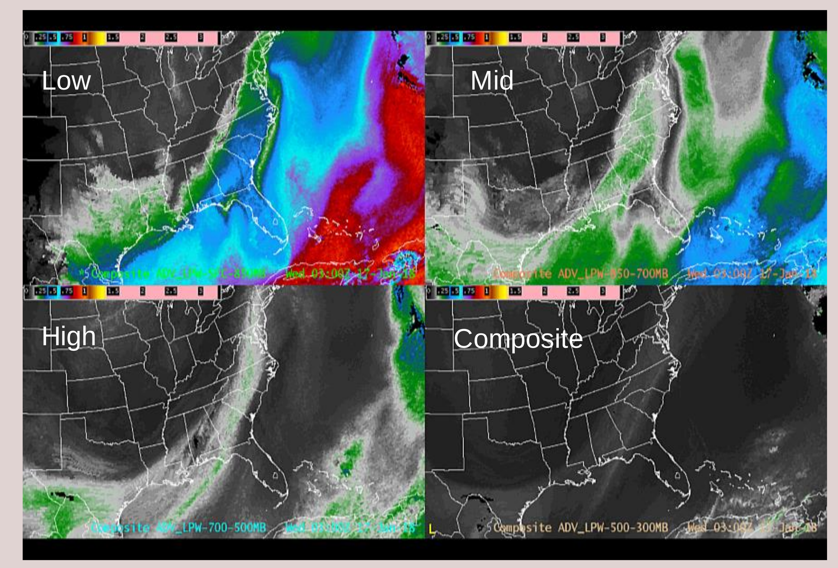


Vigorous dynamic forcing for ascent was poised to overspread the area, including upper divergence induced by a 145 kt jet streak, and falling heights at 500 hPa that would ultimately close off a low over the region. Colder air was arriving through the low and mid levels, although initial wet bulbs over eastern NC were barely below freezing. A low level wave tracking NNE along the cold front through central NC helped enhance precipitation rates.

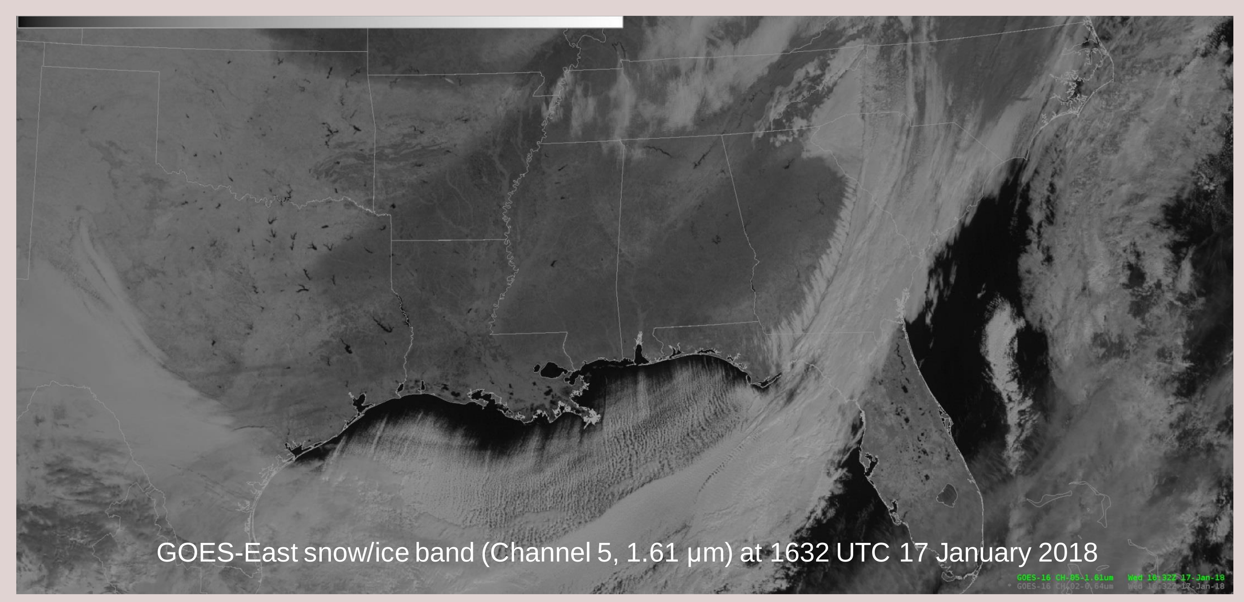
GOES-East mid level water vapor band (Channel 9, 6.9 µm) at 1200 UTC 17 January 2018



Advected Layer Preciptable Water at 0300 UTC 17 January 2018

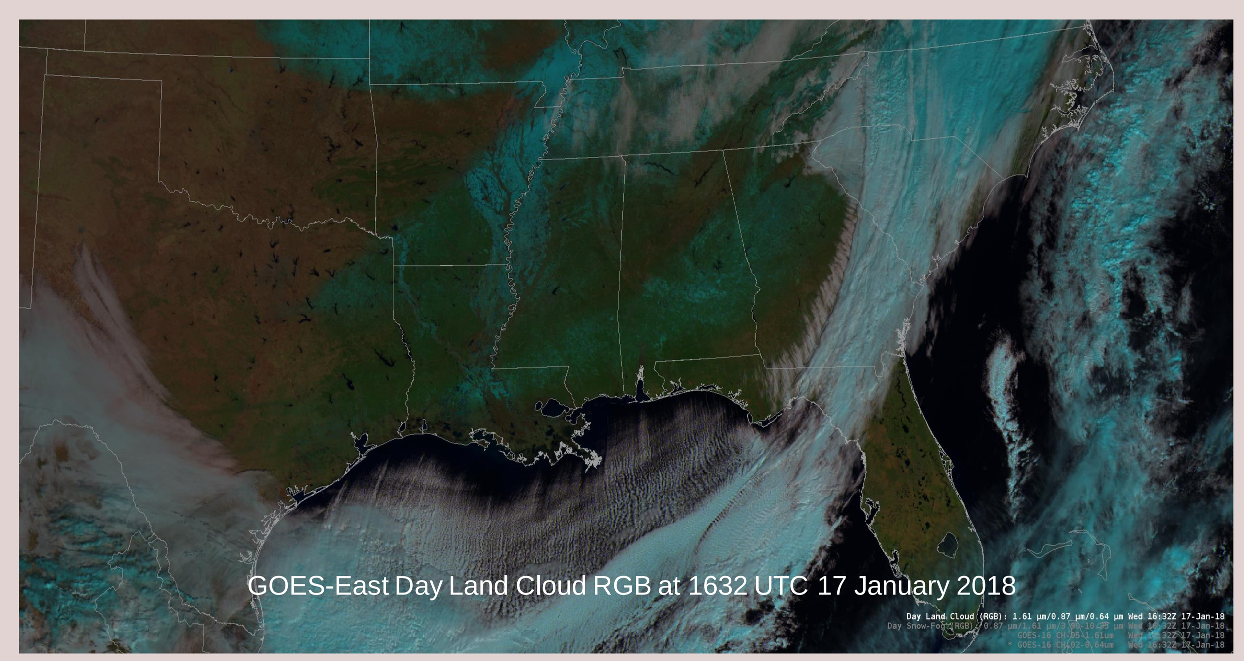


L: This band detects moisture in the 400-500 hPa range. As the event is getting underway, the digging trough to our west is evident, as is the streak of moisture ahead of the trough.
R: Precursor advected layer precipitable water (ALPW), retrieved from 7 polar orbiting satellites and advected to a common time and averaged using GFS wind forecasts, shows well the depth of moisture streaming into the region ahead of the event. The vertically aligned PW streamers signal high precipitation efficiency.



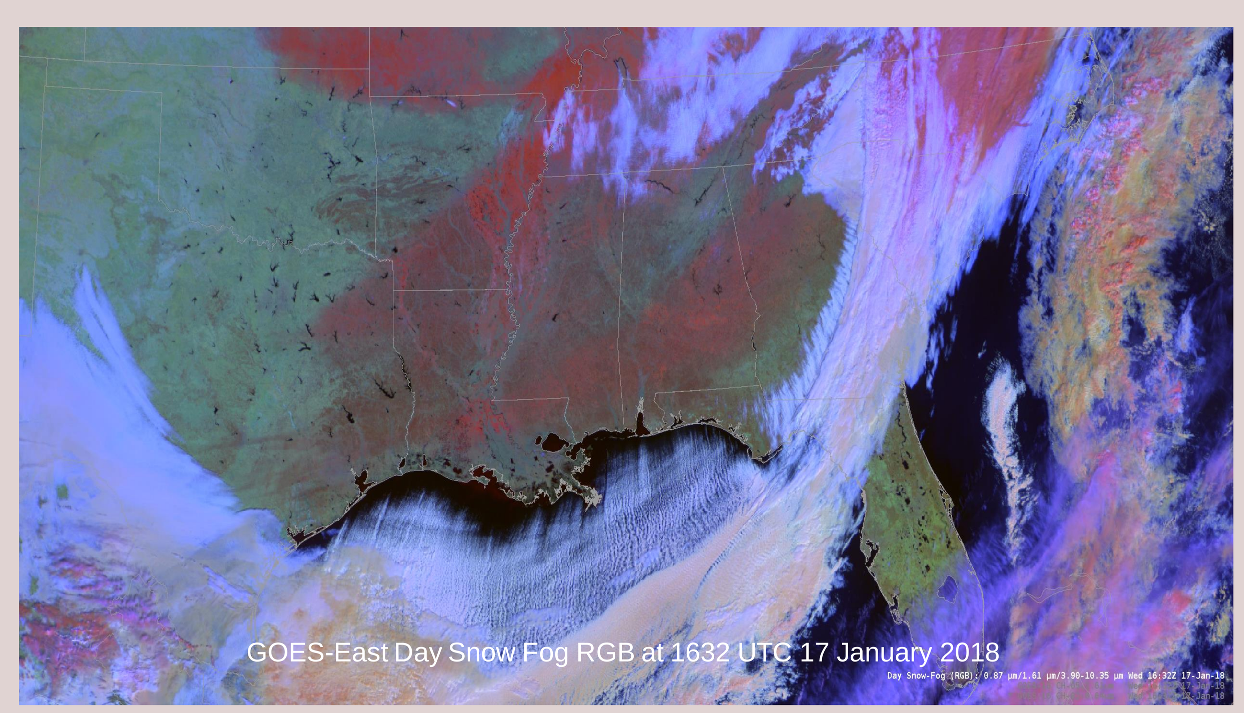
GOES-East snow/ice band (Channel 5, 1.61 µm) at 1632 UTC 17 January 2018

The presence of ice in the clouds is verified by the snow/ice band. Water clouds appear bright white, while ice clouds appear darker, as they absorb radiation at this wavelength. This, and the imagery below, helps confirm that precipitation type will likely remain as snow, as ice persists aloft.



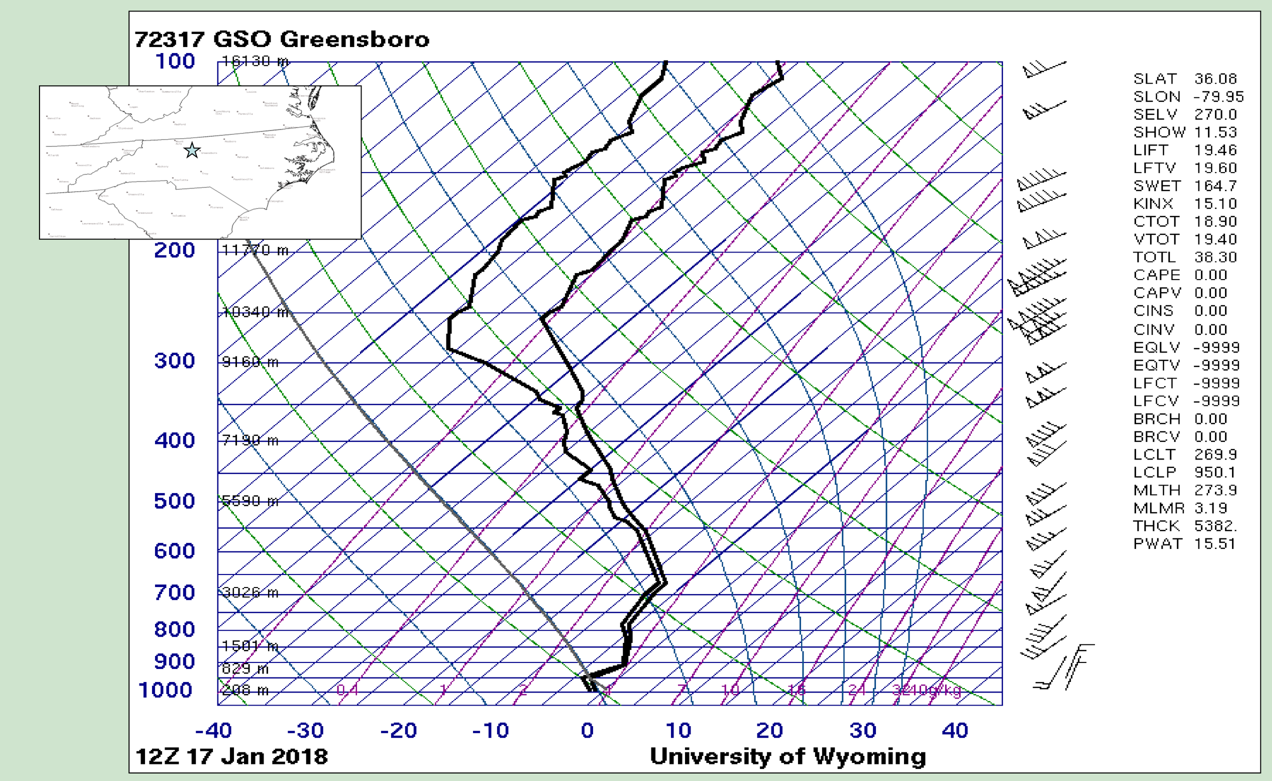
GOES-East Day Land Cloud RGB at 1632 UTC 17 January 2018

The Day Land Cloud RGB is comprised of Channels 4, 5, and 7, and is helpful for discriminating between high and low clouds. High ice clouds appear as cyan, while low water clouds are white or gray.

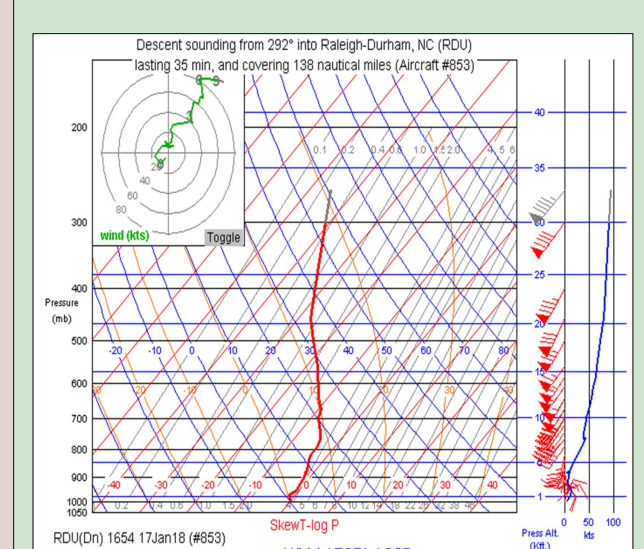


GOES-East Day Snow Fog RGB at 1632 UTC 17 January 2018

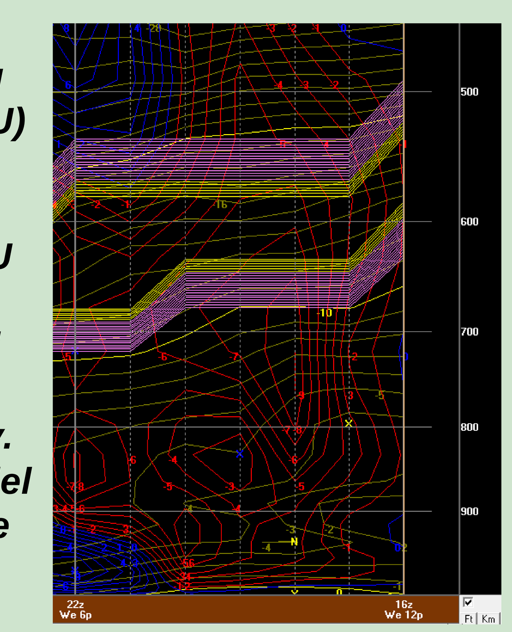
The Day Snow Fog RGB allows us to distinguish clouds from snow cover. It is built from Channels 3, 5 and the 7-13 difference. Clouds containing ice and snow appear as magenta, while low clouds (water) are a pale blue. The snow-covered ground shows up as red.



- *The 1200 UTC sounding (above) at Greensboro (inset) confirms that there was plenty of ice in the cloud, with abundant moisture at levels above (colder than) -15°C.*
- *The profile is a favorable one for heavy snow, with a deep subfreezing saturated isothermal layer in the low levels, combined with strong dynamic forcing for ascent, including within the dendritic growth zone. Conditional symmetric instability may have also contributed to ascent.*
- *The deep, saturated surface-based layer between 0°C and -5°C favors "sticky" crystals and aggregation.*
- *It is hypothesized that the likely water-coated character of the ice crystals near the ground, seeded by abundant ice aloft, promoted significant aggregation and allowed for considerable accrual of snow on trees, power lines, and other elevated surfaces, leading to power outages across the area due to snow-laden tree limbs.*
- *The brief rain-snow mix at onset and resultant wet trees and power lines may have frozen as the cooler air arrived but may have also served as added "glue" for the aggregated crystals.*



L: This AMDAR sounding near Raleigh-Durham (RDU) at 1654 UTC shows the temperature profile as heavy snow began at RDU (1+"/hr rate). The deep saturated surface-based layer just below freezing persisted through the day.
R: The 1600 UTC RAP model run at RDU shows intense snow growth during the afternoon.



Considerations and Lessons Learned

- Part of the forecast process for snow-only storms must include an assessment of snow crystal characteristics and aggregation potential, along with the potential for preceding rain that could both freeze on and "prime" the trees and power lines for accrual of snowfall.
- The potential for lift contributions from thermodynamic processes such as CSI should also be regularly assessed ahead of and during winter storms.
- The GOES-East suite of bands, channel differences, and RGBs can be used with other data sources to assess and confirm the thermal and moisture structure of the column.

References and acknowledgements: Rogers, D.C., 1974: The aggregation of natural ice crystals. Dept. of Atmos. Resources, Univ. of Wyoming. Libbrecht, K., 2005: the physics of ice crystals. Reports on Progress in Physics, 68 (4). pp. 855-895. Roebber, P. J., S. L. Bruening, D. M. Schultz, and J. V. Cortinas Jr., 2003: Improving snowfall forecasting by diagnosing snow density. Wea. Forecasting, 18, 264-287. Much thanks to Sheldon Kusselson, Juan Meng, and Dan Bikos for the ALPW imagery. Training available at http://rammb.cira.colostate.edu/training/visit/training_sessions/