Compositing Analysis of Heavy Snow Events within the St. Louis, MO County Warning Area

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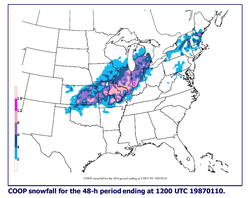
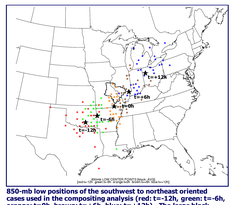
Introduction

- NOAA (2008) states that heavy snow and ice cause considerable disruptions to society because they disrupt transportation systems, utilities infrastructure, and general commerce. To alleviate the impact of these disruptions, two of NOAA's performance goals are to :
  - Increase lead time and accuracy for weather and water warnings and forecasts.
  - Improve predictability of the onset, duration, and impact of hazardous and severe weather and water events.
- Previous research such as Beebe (1956), Byrd (1989), Glass et al. (1995), Bierly and Winkler (2001), Moore et al. (2003), and more recently Thomas and Martin (2007) have shown the effectiveness of a composite analysis approach to diagnose the synoptic and mesoscale phenomena associated with certain weather events.
- In this presentation, southwest to northeast heavy snow events that affected the LSX CWA over 28 winters are analyzed using composite fields to illustrate the evolution of common features.

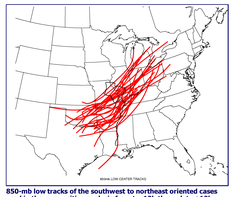


COOP snowfall for the 48-h period ending at 1200 UTC 19870110.

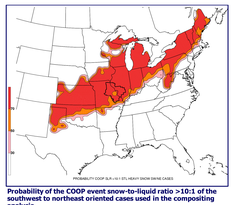
Heavy Snow Event Characteristics



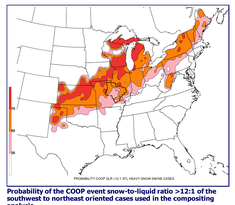
850-mb low positions of the southwest to northeast oriented cases used in the compositing analysis (red: t=-12h, green: t=-6h, orange: t=0h, brown: t=+6h, blue: t=+12h). The large black stars indicate the median positions of the 850-mb low.



850-mb low tracks of the southwest to northeast oriented cases used in the compositing analysis from t=-12h through t=+12h.

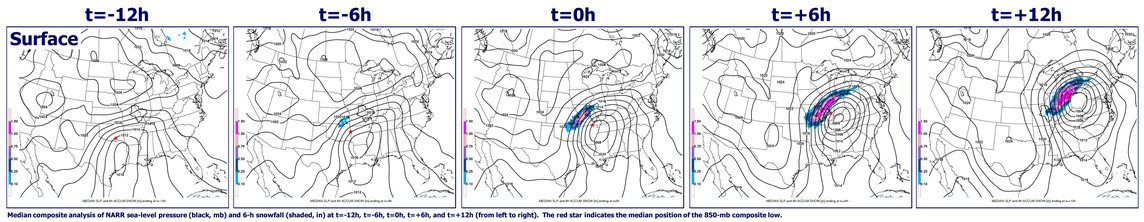


Probability of the COOP event snow-to-liquid ratio >10:1 of the southwest to northeast oriented cases used in the compositing analysis.

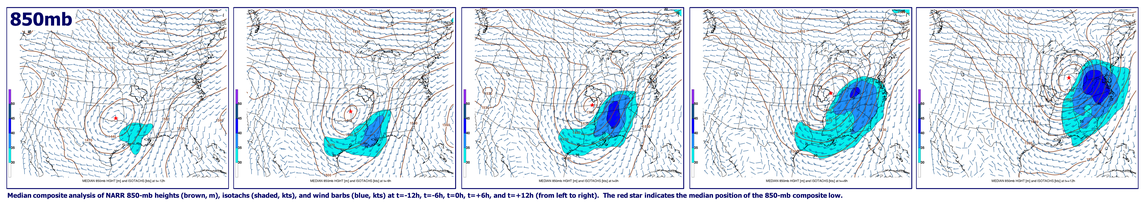


Probability of the COOP event snow-to-liquid ratio >12:1 of the southwest to northeast oriented cases used in the compositing analysis.

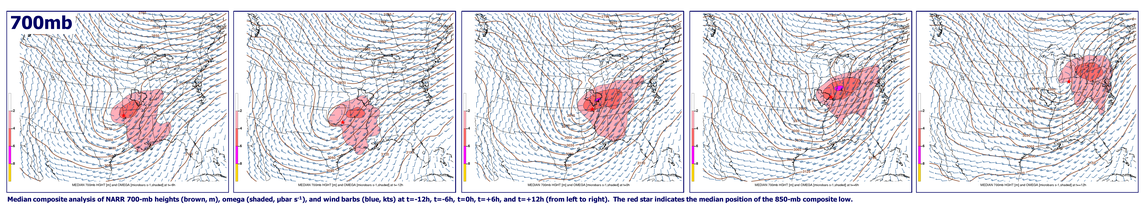
Lower-level Composites



Median composite analysis of NARR sea-level pressure (black, mb) and 6-h snowfall (shaded, in) at t=-12h, t=-6h, t=0h, t=+6h, and t=+12h (from left to right). The red star indicates the median position of the 850-mb composite low.



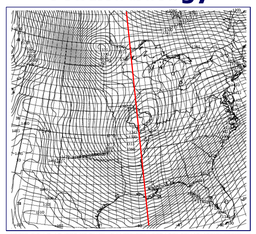
Median composite analysis of NARR 850-mb heights (brown, m), isotachs (shaded, kts), and wind barbs (blue, kts) at t=-12h, t=-6h, t=0h, t=+6h, and t=+12h (from left to right). The red star indicates the median position of the 850-mb composite low.



Median composite analysis of NARR 700-mb heights (brown, m), omega (shaded, μbar s^{-1}), and wind barbs (blue, kts) at t=-12h, t=-6h, t=0h, t=+6h, and t=+12h (from left to right). The red star indicates the median position of the 850-mb composite low.

Methodology

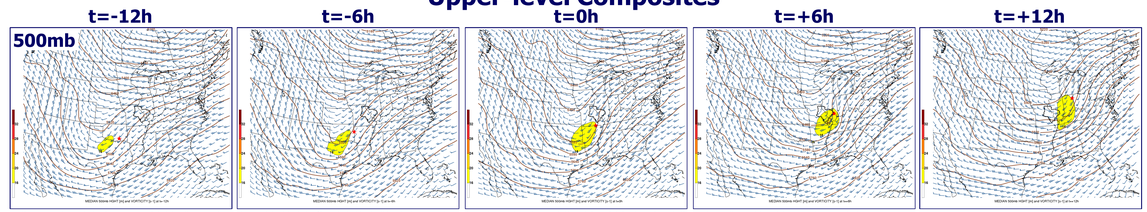
- Examination of the COOP Event Snow database maps developed by Saint Louis University (see example in introduction) revealed that 55 heavy snow events (>6") occurred in the LSX CWA between the winters of 1980/1981 and 2007/2008.
- The heavy snow events were then classified by band orientation. The events in question were oriented southwest to northeast (34 events), west to east (18 events), northwest to southeast (2 events), and south to north (1 event). The southwest to northeast oriented events are examined in this presentation.
- Using the General Meteorological Package (GEMPAK) with the North American Regional Reanalysis (NARR) , system-relative composites were generated using software developed by Saint Louis University.



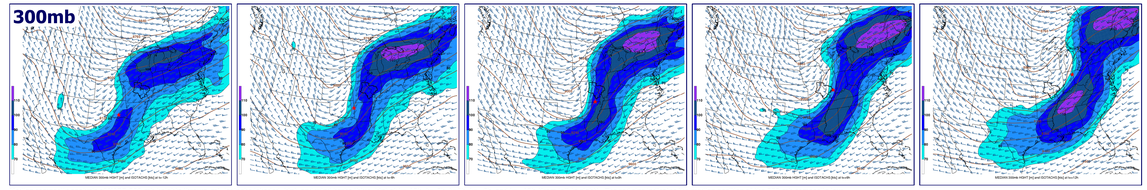
Example of initial analysis (t=0h) time and location for the heavy snow event on 19 January 1987 at 0900 UTC using the 850-mb height field. Red line denotes location of the 91st meridian.

- An initial analysis time (t=0h) for each southwest to northeast oriented heavy snow event was defined as the time when the 850-mb low was closest to the 91st meridian (see image to left).
- The locations of the 850-mb lows for the 30 southwest to northeast oriented events (4 events were omitted due to an undefinable 850-mb circulation) were used as the center of the compositing grid.
- In addition, the locations of the 850-mb lows were also utilized for system-relative composites at t=-12h, t=-6h, t=+6h, and t=+12h.
- Finally, the median latitude and longitude positions of the 850-mb lows at each time were used to display the resulting composite fields in a geographical framework.

Upper-level Composites

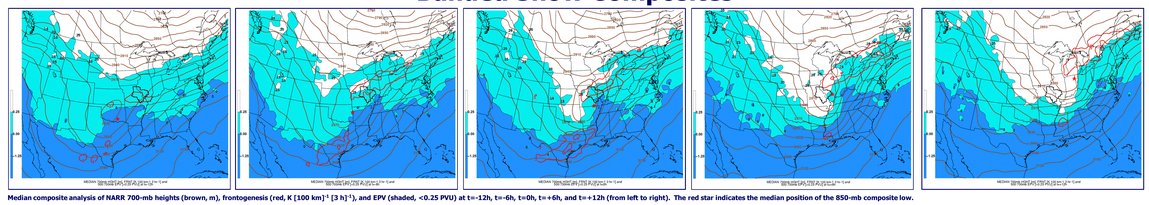


Median composite analysis of NARR 500-mb heights (brown, m), relative vorticity (shaded, s^{-1}), and wind barbs (blue, kts) at t=-12h, t=-6h, t=0h, t=+6h, and t=+12h (from left to right). The red star indicates the median position of the 850-mb composite low.



Median composite analysis of NARR 300-mb heights (brown, m), isotachs (shaded, kts), and wind barbs (blue, kts) at t=-12h, t=-6h, t=0h, t=+6h, and t=+12h (from left to right). The red star indicates the median position of the 850-mb composite low.

Banded Snow Composites



Median composite analysis of NARR 700-mb heights (brown, m), frontogenesis (red, K [100 km]$^{-1}$ [3 h]$^{-1}$), and EPV (shaded, <0.25 PVU) at t=-12h, t=-6h, t=0h, t=+6h, and t=+12h (from left to right). The red star indicates the median position of the 850-mb composite low.

Conclusions

- The composite analysis depicts features and their evolution that are representative of an individual event.
- The 850-mb low tracks along the southeastern extent of the CWA with the heaviest snow occurring (t=0 – 6h) when the low is to the east of the 91st meridian.
- The snow-to-liquid ratio exceeds 10:1 in over 70% of the cases and exceeds 12:1 in about 50% of the cases.
- The composite fields portray a 3D mid-latitude cyclone with westward tilt, that continues to intensify through the duration of the compositing period.
- Furthermore, the composites characterize a system that contains the coupled upper-level jet streak pattern that is associated with East Coast heavy snow events.
- The evolution of EPV shows weak-symmetric stability tending toward CSI with stable air advection southward behind the system. The frontogenetical signal is most pronounced at t=-6 – 0h with the axis paralleling the track of the 850-mb low, which suggests the potential for a heavy snow swath.
- Future research entails an analysis of upper-level potential vorticity including its relationship to mid-latitude cyclone development and the application of the compositing analysis of winter storms to other geographical areas.