[596] Relationships Between Synoptic-Scale Circulation Features and Upstream Air Trajectories Associated with Winter Storms in Central North Carolina

Chris Fuhrmann[1], Chip Konrad[1], *and Josh Durkee[2]*

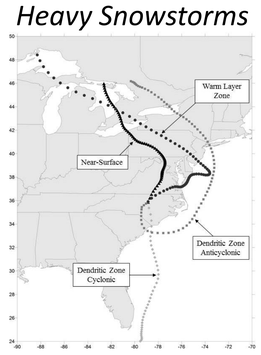
[1] Southeast Regional Climate Center, Department of Geography, University of North Carolina at Chapel Hill

[2] Meteorology Program, Department of Geography and Geology, Western Kentucky University

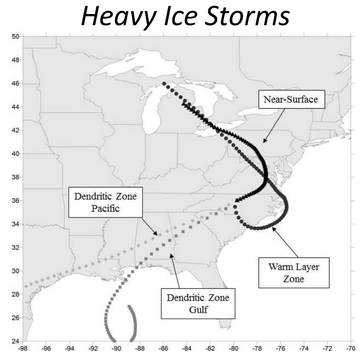
Background and Motivation

- Recent research (Fuhrmann and Konrad 2013) has shown that air parcel trajectory analyses are useful for assessing the ingredients (i.e. temperature, moisture, lift) and meteorological processes that come together to produce heavy winter storms in central North Carolina

Heavy Snowstorms



Heavy Ice Storms

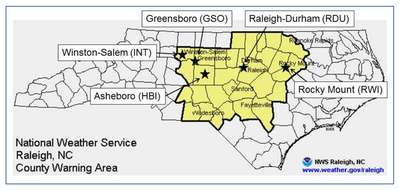


Near-surface trajectories *(ending at 975 hPa) reveal the circulation within the low-level cold wedge that is typically present during winter precipitation in the region.* ***Warm layer zone trajectories*** *(ending at 850 hPa) are critical for determining precipitation type, as above (below) freezing temperatures in this zone are typically associated with freezing rain (snow). Trajectories associated with the* ***dendritic growth zone*** *(ending at the mean pressure with temperature between -13 and -17°C) reveal the properties of the air associated with ice crystal formation and growth which, when combined with sufficient moisture and upward vertical motion, can lead to heavy precipitation.*

- While the details of the trajectory motions and characteristics have been shown to influence the type of precipitation that accumulates, examination of a sufficiently large sample of storms of varying intensities is needed to better establish climatologically robust relationships between the trajectories and resulting precipitation characteristics.
- Additionally, because air parcel trajectories have been shown to be good indicators of synoptic-scale circulation regimes (Roberge et al. 2009), it is likely that various features of the large-scale circulation, such as the position and orientation of troughs and ridges, as well as the tracking and intensity of surface cyclones and anticyclones, are useful in predicting those trajectory motions tied to specific precipitation characteristics.

Data and Methods

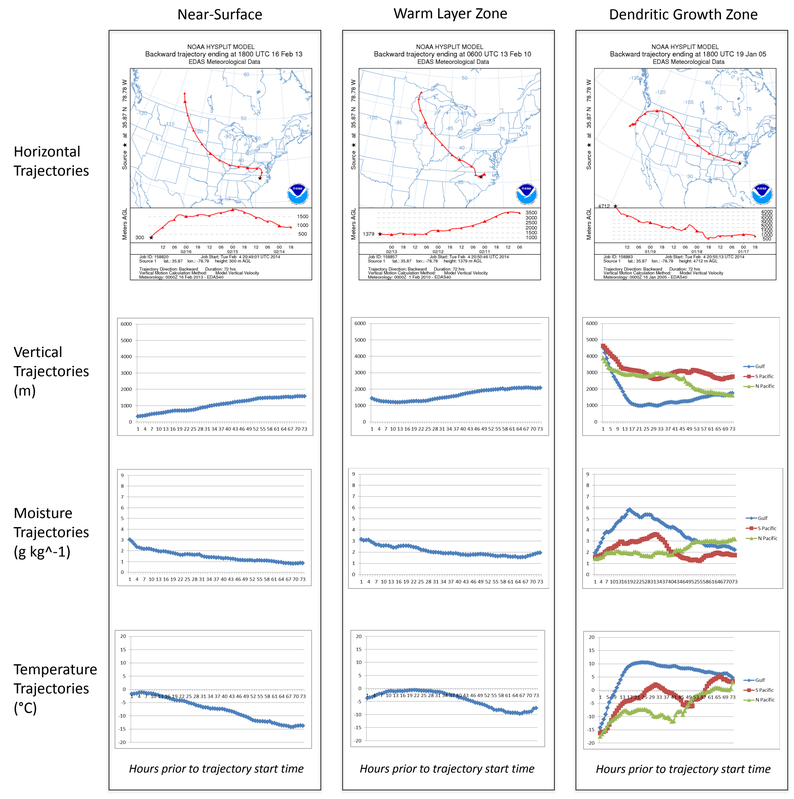
- As in Fuhrmann and Konrad (2013), this study focuses on the Raleigh, NC National Weather Service County Warning Area (CWA), a highly-populated region covering 31 counties in central North Carolina (see figure below) .
- Events (i.e. snowstorms and ice storms) were selected from an online archive of detailed precipitation maps of winter storms affecting the CWA (http://www.erh.noaa.gov/rah/events).
- The table below summarizes several characteristics of the events examined in this study, including the thresholds used to define heavy and light events.
- 72-hour back trajectories for each event were calculated using version 4.9 of NOAA's HYSPLIT tool, which was initialized using NCEP's EDAS/NAM system (40 and 80 km).
- To determine the synoptic-scale circulation and thermodynamic features associated with these events, composite plots were analyzed using data from the North American Regional Reanalysis.



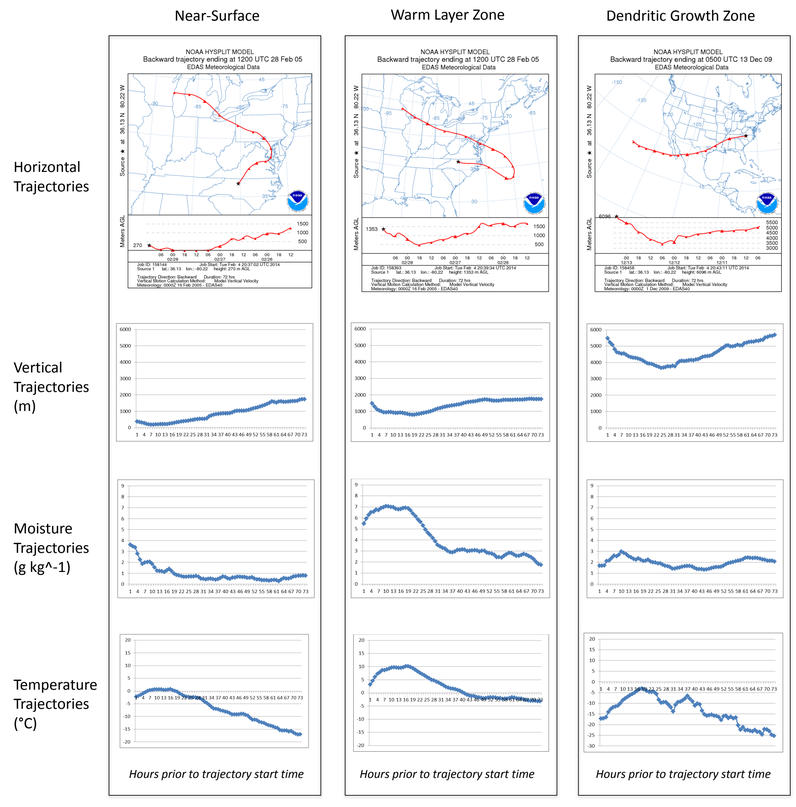
	Heavy Snow	Light Snow	Heavy Ice	Light Ice	Transition (Snow to Ice)
N	8	19	7	6	5
Median Event Precipitation (in)	12.0	1.0	1.00	0.35	1.1
Max Event Precipitation (in)	20.0	3.0	6.00	1.00	2.3
Median Event Duration (h)	15.5	4.5	24.0	13.5	9.5
Max Event Duration (h)	27.0	8.0	32.0	21.0	18.0
Median Precipitation Rate (in/h)	0.08	0.02	0.11	0.03	0.04
Max Precipitation Rate (in/h)	0.12	0.05	0.22	0.09	0.10

Trajectory Analyses

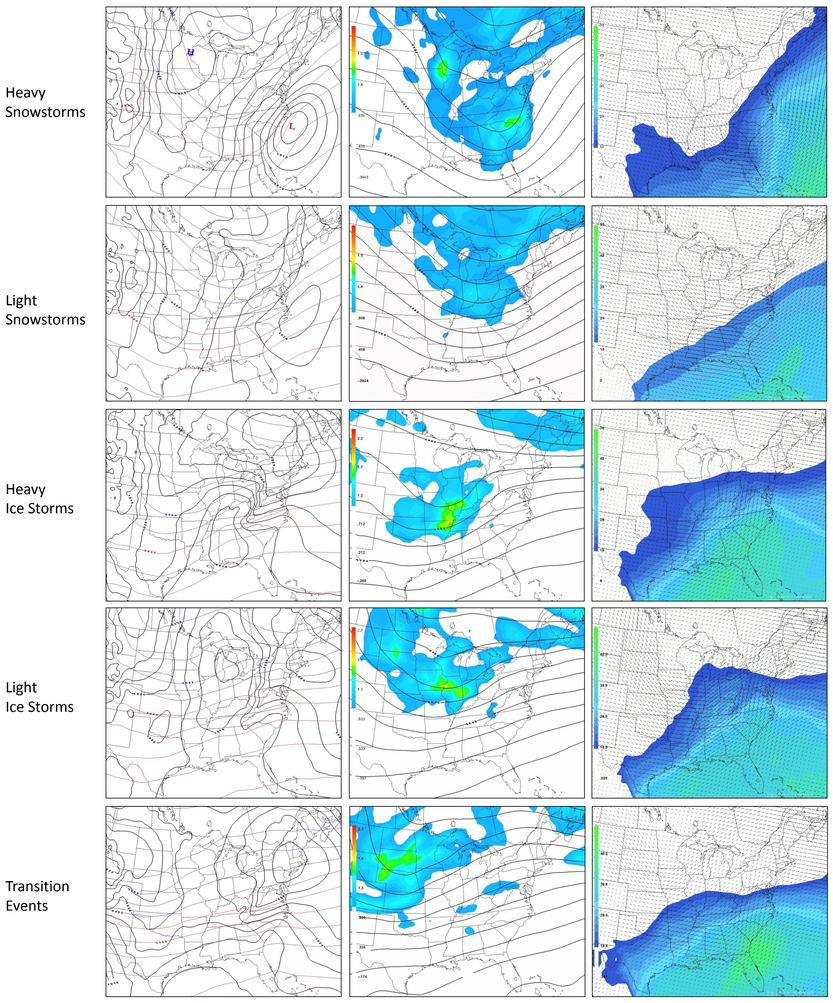
Light Snowstorms



Light Ice Storms



Synoptic Analyses



Composite 1000-500 hPa thickness (thin lines; ≤ 5400 dam colored blue, > 5400 dam colored red) and mean sea level pressure (thick line, hPa)

Composite 500 hPa geopotential height (black lines, dam) and absolute vorticity (shaded, 10^-5 s^-1)

Composite 850-700 hPa layer-averaged wind (arrows, m s^-1) and total column precipitable water (shaded, mm)

Conclusions

- Snowstorms:
  Key differences between heavy and light events were noted in the dendritic growth zone trajectories, where 11 of 19 light events were associated with a trajectory that extended off of the Pacific Northwest, exhibited relatively weak lift (weaker cyclone), and much less moisture than the heavier events. However, the remaining light snowstorms did exhibit trajectory characteristics that typify the heavier sample. In these cases, the lower precipitation amounts may be a function of event duration and drier low-level air.
- Ice Storms:
  Again, key differences between heavy and light events were noted in the dendritic growth zone trajectories. Light events were associated with a single Pacific trajectory that exhibited similar moisture contents, but lower vertical velocities, a weaker CAD signature, and lower amplitude short-wave troughs. Interestingly, both warm (WLZ) and cold (DGZ) cloud precipitation processes appear to be present in both heavy and light ice storms.

References:

- Fuhrmann, C.M. and C.E. Konrad II, 2013: A trajectory approach to analyzing the ingredients associated with heavy winter storms in central North Carolina. *Weather and Forecasting*, **28**, 647-667.
- Roberge, A., J. Gyakum, and E. Atallah, 2009: Analysis of intense poleward water vapor transport into high latitudes of western North America. *Weather and Forecasting*, **24**, 1732-1747.