Storm Structures and Precipitation Characteristics of Snow Events in the Southern Appalachian Mountains

Sandra E. Yuter [(1)], L. Baker Perry [(2)], David A. Stark [(1)], M. Tai Bryant [(1)]
(1) Department of Marine, Earth, and Atmospheric Sciences, North Carolina State University
(2) Department of Geography and Planning, Appalachian State University

I. Introduction and Background

- The purpose of this project is to examine the natural variability of the physical characteristics of precipitation during snow events in the southern Appalachians. Results from the analysis will be used to improve understanding of the physics of snow and to improve model forecasts of snow events.
- A meteorological tower, vertically-pointing MicroRainRadar (Ku-band), OTT weighing rain gauge, and a PARSIVEL disdrometer were placed at Poga Mountain, NC, located near the crest of the Appalachian Mountains. The meteorological tower was placed near mountain top at an elevation of 1137 m. The other instruments were downslope a short distance away at an elevation of 1021 m.
- During the 2006-2007 snow season, there were 20 snowfall events at Poga Mountain with accumulations ranging from 2 mm to 147 mm. Sixteen of the 20 events had winds out of the northwest, which is perpendicular to the mountain slopes.

II. Instrumentation

Figure 1: Meteorological tower on the top of Poga Mountain

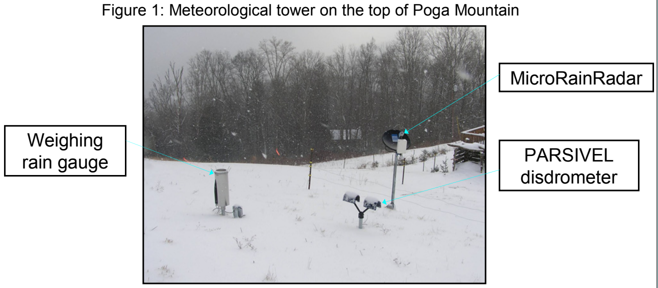


Figure 2: Precipitation instruments during a light snow event

III. Location

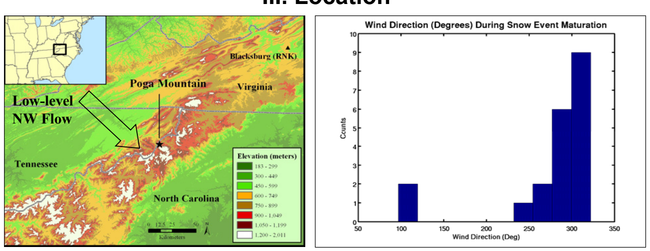
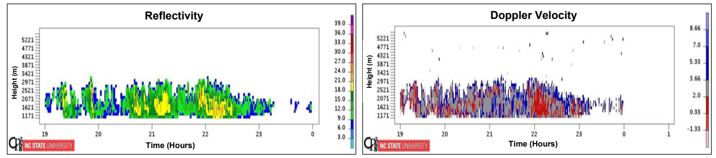


Figure 3: Regional topographic map (left) showing location of Poga Mountain, NC includes a schematic of low-level northwest flow relative to the mountain range. Blacksburg (RNK) is the location of the upper air sounding data used in this study. Histogram (right) showing the distribution of wind direction at storm maturity for the 20 snowfall events.

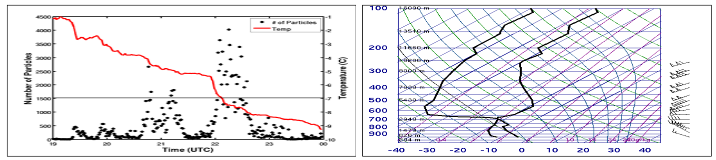
IV. Data

A. 19 UTC 07 December 2006 – 00 UTC 08 December 2006

Snowfall: 51 mm; Snow water equivalent: 2.3 mm; Snow Z layer depth: 3121 m



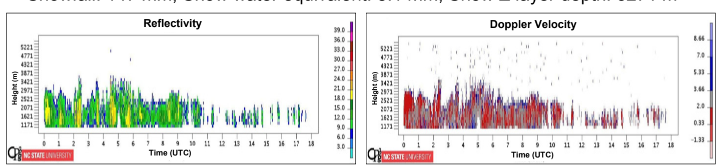
Time-height plots of reflectivity (Z) and Doppler velocity (Vr=w+Vt) where Vr is measured Doppler velocity (positive downwards), w is vertical air motion and Vt is fall speed of particles. For snow Vt~2 ms^{-1} so Vr< 2 ms^{-1} indicates regions of upward motion.



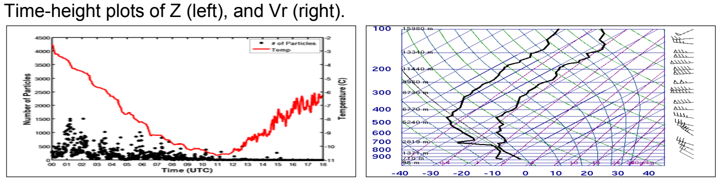
Time series of temperature vs. number of particles (left) shows a decreasing trend in temperature and intermittent pulses of increased particle number. Horizontal line represents the maximum number of particles for event B. Upper air sounding (right) from RNK at 00 UTC 8 December 2006 shows an inversion present at 3218 m, similar to the height of the top of the snow layer.

B. 00 UTC 07 April 2007 – 18 UTC 07 April 2007

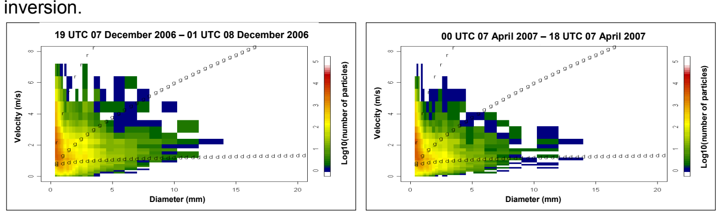
Snowfall: 147 mm; Snow water equivalent: 8.1 mm; Snow Z layer depth: 3271 m



Time-height plots of Z (left), and Vr (right).

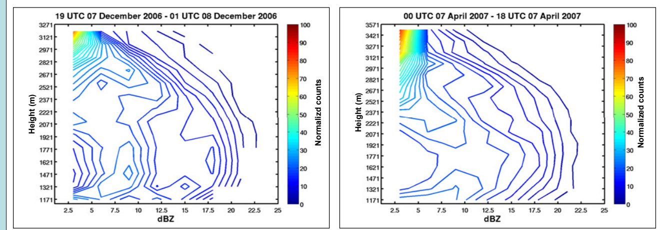


Time series of temperature vs. number of particles (left) shows a decreasing temperature trend with a minimum of -10.7°C at 11 UTC which then increases to -6.2°C by the end of the event. There are significantly fewer particles per unit time than during event A. Upper air sounding (right) from RNK at 12 UTC 7 April 2007 shows no inversion.

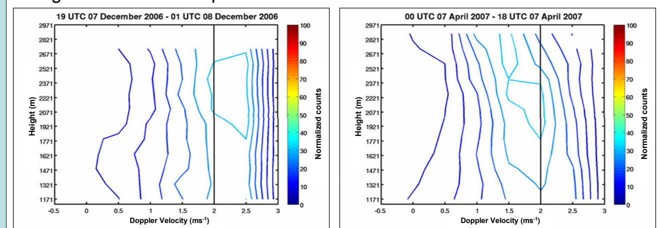


PARSIVEL matrix plots of number of particles in each measured size and fall speed category for events A and B. Empirical fall speed relations for rain (r), dendrites (d), and graupel (g) are indicated.

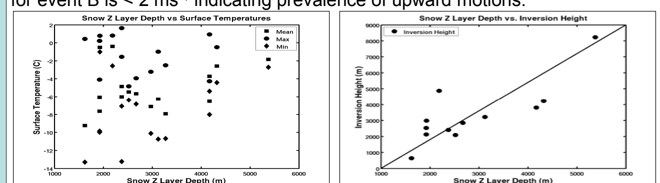
V. Results



Contoured frequency by altitude diagrams (CFADs) of reflectivity for events A and B. Increasing Z values with decreasing height indicate particle growth while vertical contours indicate little to no growth. Modal reflectivities are slightly stronger for event B compared to event A.



CFADs for Doppler velocity for events A and B. The frequency distribution mode for event B is < 2 ms^{-1} indicating prevalence of upward motions.



For each snow event, snow Z layer depth is plotted versus the mean, maximum, and minimum surface temperature (left). For 12 storms with inversions, snow Z layer depth is plotted versus inversion height from RNK soundings.

VI. Conclusions

- 85% of the snow storms during the 2006-2007 winter season had low-level NW flow at maturation. These storms yielded 91% of the total season snow water equivalent (SWE).
  - SWE to snow depth ratio varied from 0.02 to 0.5.
- Most of the snow storms at Poga Mountain were shallow with 14 out of 20 storms having 3 dBZ radar echo heights less than 2.5 km above ground level (3 km MSL).
- When inversions were present, snow Z layer depth was strongly correlated to inversion height.
- There was no clear relation between snow Z layer depth and surface air temperature (mean, maximum, minimum).
- The number of snow particles at the surface varied widely among storms and within individual storms. Pulses of large numbers of particles (>2500 min^{-1}) at the surface were associated with stronger Z values and more upward motions.
  - Snow particles greater than 10 mm diameter were produced by shallow Z layers < 2.5 km AGL but most particles at the surface were less than 1 mm diameter.
- The relationship between upward air motions and modal reflectivities in the column above the site varied.

VII. Acknowledgements

Thanks to David Spencer, Daniel Horn, Gerhard Peters, and Casey Burleyson for hardware and software support and advice. This study was supported by NSF grants ATM-0544766 and GEO-0303195 and NCSU startup funds.