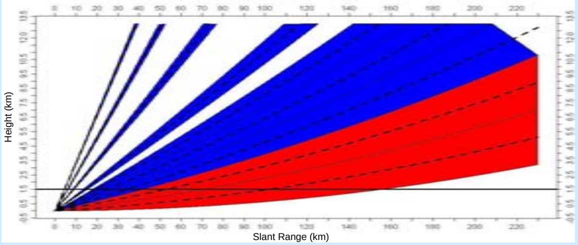
Statistical Analysis of Vertical Profiles of Precipitation

Casey D. Burleyson
Cloud and Precipitation Processes and Patterns Group
Department of Marine, Earth and Atmospheric Sciences, North Carolina State University

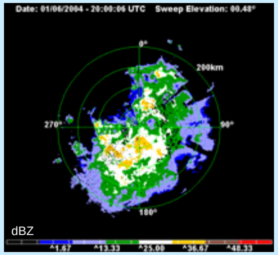
Motivation

National Weather Service (NWS) radars are used to provide quantitative precipitation estimates from passing storms. These radars scan the atmosphere from altitudes of a few hundred meters to several kilometers. However, the NWS radars are unable to distinguish conditions in which precipitation at the lowest level scanned evaporates before reaching the surface. This ambiguity leads to uncertainties in storm accumulated precipitation and seasonal precipitation estimates. This project uses a statistical analysis of vertically pointing radar returns at varying height levels to investigate the probability of rainfall at the surface for moderate and weak radar echo aloft.

- Quantitative precipitation estimates using radar provide better spatial and temporal resolutions than rain gauges. Radar derived estimations are important to operational meteorologists for monitoring heavy rainfall conditions.
- Virga is precipitation falling from clouds that evaporates before reaching the surface.
- Virga returns on scanning radars are indistinguishable from precipitation reaching the surface and their values are erroneously counted towards precipitation estimates.



Volume Coverage Pattern of a NWS radar. At a range of 160 km the radar is only intercepting precipitation at heights above 1.5 km altitude.



Scanning radar observation from Portland, Oregon on 1/6/04. A forecaster analyzing this scan cannot be certain that precipitation is occurring at the surface in areas of weaker reflectivity (shaded green, gray, and blue; <25 dBZ).

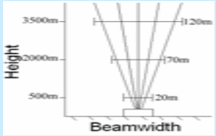
Objectives

- Determine if there is a significant statistical relationship between radar returns at higher levels and rainfall rate (RR) at the surface.
- Develop a method of identifying probable virga events and accounting for them in the precipitation estimates derived from the scanning radar.

Instruments

Data was collected at Scholls, Oregon in 2005 by a vertically pointing METEK Micro Rain Radar (MRR) and accompanying JW disdrometer, which measures rainrate. Data from both instruments are obtained every minute.

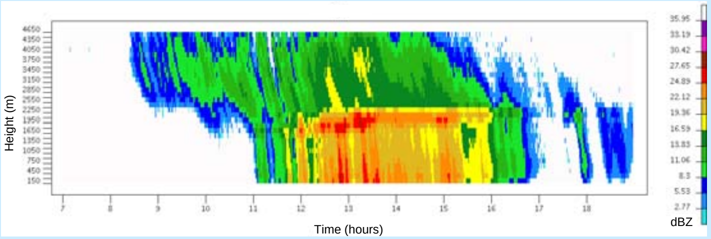
MRR observes a profile of the atmosphere



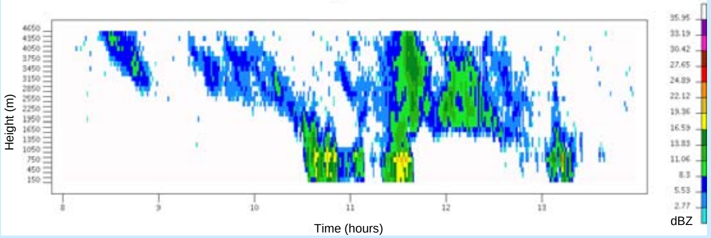
Scanning profile of the MRR

JW disdrometer collects precise rainrate data

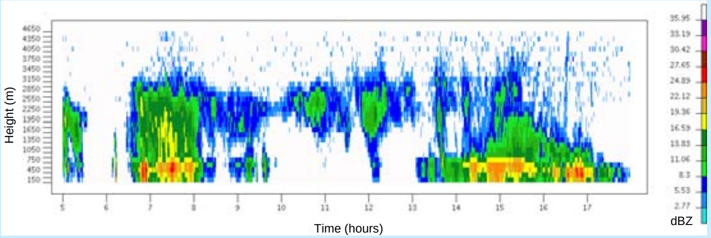
Data



Time-Height plot from a virga event on 4-25-05. Reflectivity values indicate rainfall aloft just before 9 UTC. However the precipitation is evaporating near the 0°C height level and does not appear at the surface until 11 UTC. The first traces of precipitation are measured at the surface at 10:30 UTC. Shortly after 11 UTC the rainrate increases steadily then plateaus for the remainder of the period



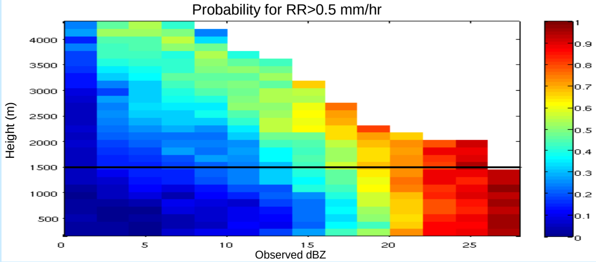
Event on 4-05-05 where precipitation starts as virga after 8:20 UTC. Precipitation eventually falls to the surface at 10:30 UTC but switches back to virga near 11:40 UTC



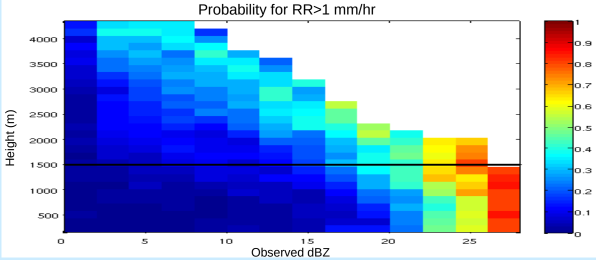
In this case from 2-06-05 two periods of precipitation at the surface are separated by a 5 hour stretch of evaporating precipitation above 1650 m altitude.

Results

Statistical analysis combines data for 79 days from January 9th, 2005 through April 30th, 2005. Data are organized into two groups, RR>0.5 mm/hr with 19,582 ten minute profiles and RR>1 mm/hr with 10,928 ten minute profiles. A minimum of 50 profiles were used to calculate probabilities at a given height.



For 1.5 km altitude, reflectivity values must be greater than 16 dBZ for rainfall probability (RR>0.5 mm/hr) at the surface to be greater than 50%



For 1.5 km altitude, reflectivity values must be greater than 22 dBZ for rainfall probability (RR>1 mm/hr) at the surface to be greater than 50%

Conclusions

- Probabilities increase with height for a given dBZ echo
- Probabilities increase with reflectivity for a given height level
- Increasing the rain rate threshold decreases the overall probability at all height and dBZ levels

Future Work

- Condition the probabilities on the height of the freezing level at the time of the observation.
- Apply method to other geographic locations to determine regional variations in results.

Contact Information

Casey D. Burleyson
cdburley@ncsu.edu
919.512.1449

Faculty Advisor: Dr. Sandra Yuter
sandra_yuter@ncsu.edu
919.513.7963