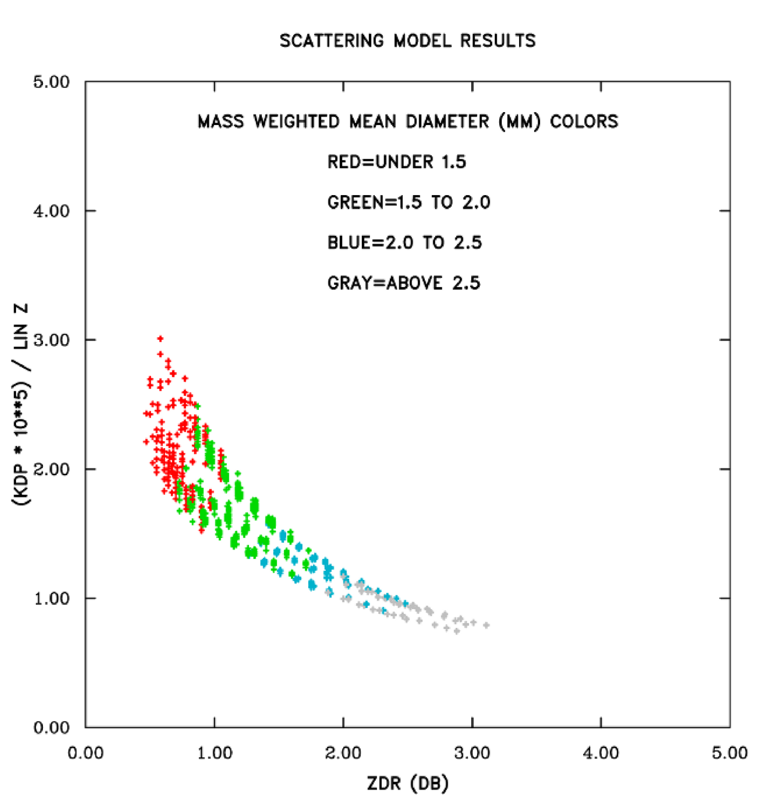
THE USE OF POLARIMETRIC RADAR DATA TO CHARACTERIZE DROP SIZE DISTRIBUTION REGIMES IN MODERATE – HEAVY CONVECTIVE RAIN

PATRICK C. KENNEDY, V. CHANDRASEKAR, AND S. A. RUTLEDGE*

OVERVIEW

Motivation:
The polarimetric parameter space defined by Kdp/Z vs. Zdr has been shown to be useful in characterizing raindrop shapes (Gorgucci et al., 2006). This paper examines the utility of this parameter space for the differentiation of convective rain developing under "warn rain" environments (high freezing level / active drop collision-coalescence processes) from rain forming in "cold rain" conditions where melting ice particles play a major role in precipitation formation.

Scattering Model Experiments
1942 CSU CANTMAT model runs at 3 GHz radar frequency
Variable input parameters:
•Nw 2000 to 11000 mm^{-1} m^{-3}
•Gamma distribution mu values from -1 to 5
•Dm 1.2 to 3.5 mm
•Beard and Chuang (1987) or Andsager et al (1999) drop shapes.
•Canting angle standard deviations of 5 and 10° about 0° mean.
Points in the scatter plot shown below are restricted to a Kdp range 0.05 to 8° km^{-1}. The Z value range is 32 to 60 dBZ and the Zdr range is 0.47 to 3.1 dB.



As found in Gorgucci et al (2006), drop size distribution variations, especially Dm, occur along well-defined, curving paths in Kdp/Z vs. Zdr space

RADAR OBSERVATIONS

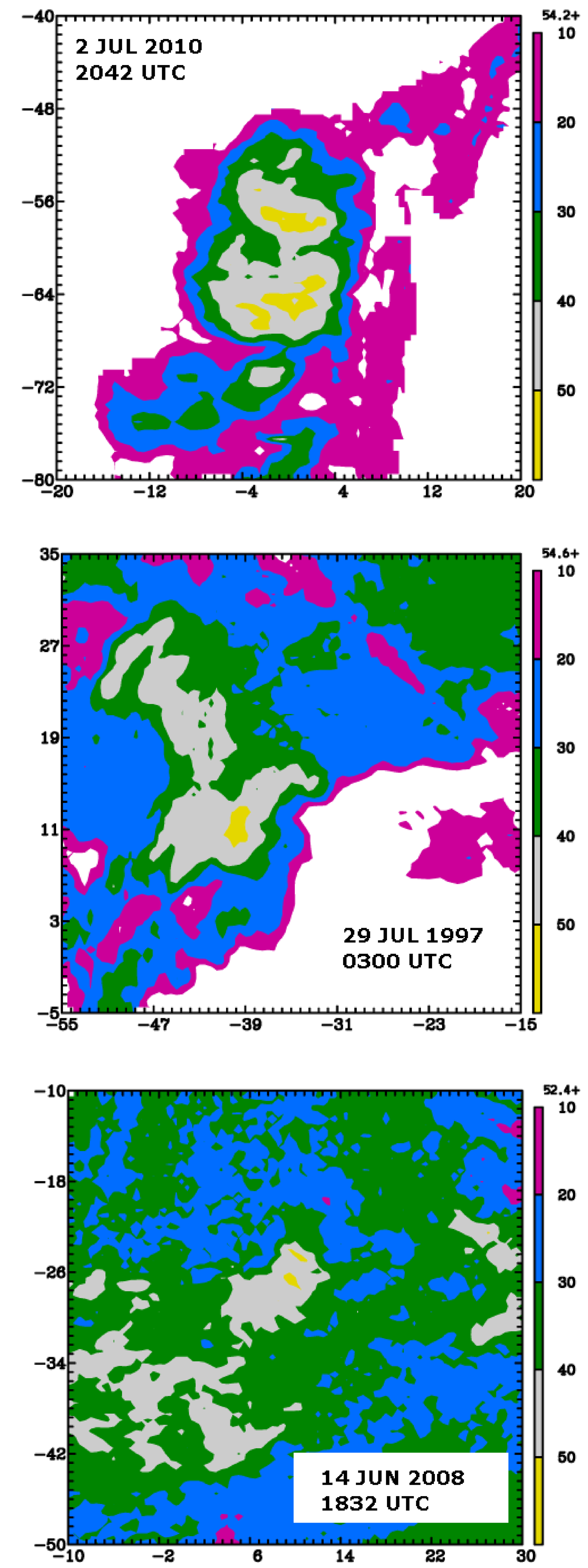
Dual-polarization S-Band data sets from cold and warm rain regimes:

•2 July 2010 2017-2115 UTC 0.5° elevation CSU-CHILL observations of thunderstorm development that followed a gust front collision near KDEN. The storm developed in a typical summer high plains sounding environment where cold rain processes are important.

•29 July 1997 0201-0315 UTC 1.6° elevation CSU-CHILL data collected during flash flooding in Ft. Collins. A tropical type air mass advected into the Colorado Front Range area during the late summer monsoon season. Warm rain precipitation processes were active. (Petersen et al., 1999)

•14 June 2008 1816-1857 UTC 1.5° elevation NCAR S-Pol data from Taiwan during TiMREX. An extensive rain area with embedded convective cores was observed in a maritime tropical environment at ~23° N latitude. These conditions imply that raindrop formation via the warm process is expected.

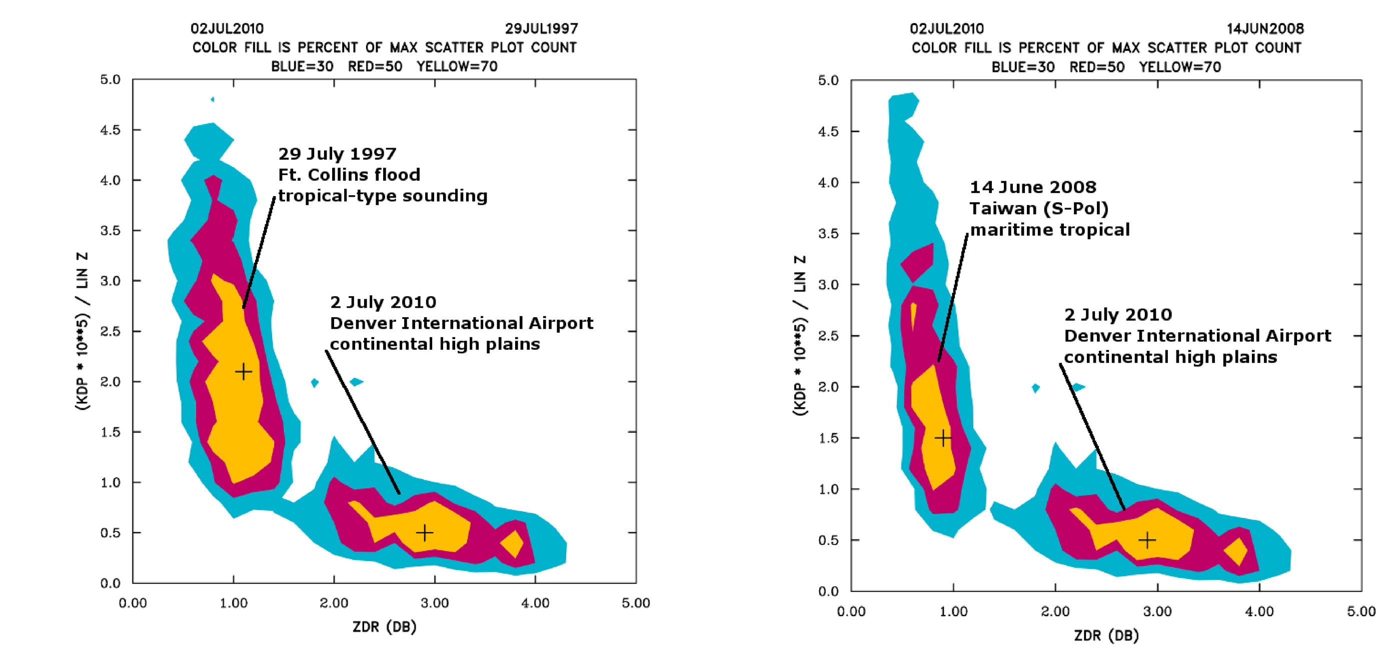
Data Processing:
•Only low elevation angle (0.5 – 1.6°) PPI sweeps used keep the sample volume height below the 0°C height.
•Domain selection to avoid clutter, blockage, hail, etc.
•Kdp calculated using the adaptive Kdp technique of Wang and Chandrasekar (2009).
•Interpolation to 0.5 km by 0.5 km Cartesian grid on the PPI surface using NCAR SPRINT software.
•Reflectivity lower threshold of 30 dBZ imposed to reduce the inclusion of noisy Kdp estimates.
•Gridded data files output for sweep 1 of all of the volumes available during each analysis period.



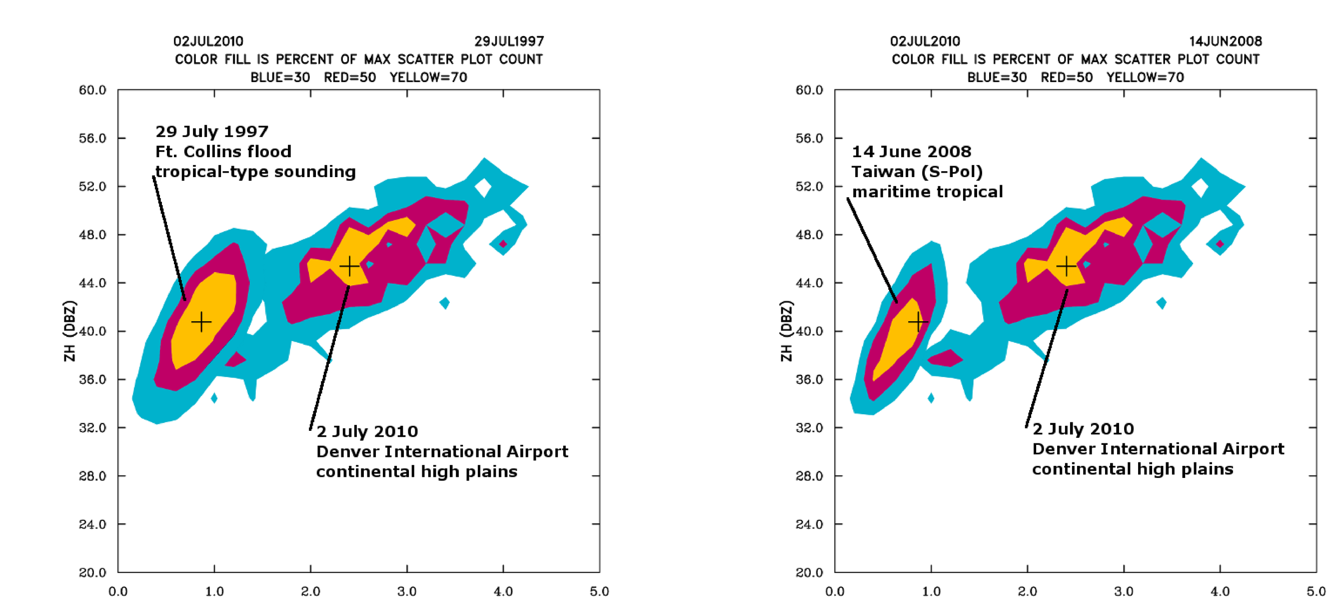
Above: Example gridded PPI plots of the reflectivity data (in dBZ) from the three cases. Axes units are in km from the radar.

RAIN REGIME DELINEATIONS

Scatter plots were generated from the gridded PPI polarimetric data fields. The scatter plot domain was divided into a 25 x 25 mesh of square sub-regions. Counts of the number of scatter plot points falling into each sub-region box were developed. A representation of scatter plot density was obtained by dividing the point count in each box by the maximum recorded point count. These count densities are contoured in the following plots; the location of the maximum point count box is marked with a +



The two plots above compare the Kdp/Z vs. Zdr scatter plot point densities for the two warm rain cases (29 July 1997 and 14 June 2008) with that of the continental high plains case (2 July 2010). The distribution of the two rain regimes is in general agreement with the shape of the curves in the scattering model experiments:



The two plots above show the same PPI data plotted in Z vs. Zdr space; a polarimetric variable combination that has also been used for rain characterization (JPOLE, 2003). The separation between the two rain regimes is less distinct in the Z vs. Zdr domain.

DISCUSSION

The Kdp/Z vs. Zdr parameter space provides a setting in which variations in the mass-weighted mean diameter of a population of raindrops produce constrained displacements. In particular, these displacements take place primarily along curving paths that are determined by the drop shape – diameter relationship (Gorgucci, et al., 2006). Scatter plots constructed in the Kdp/Z vs. Zdr domain show a clear response to the increased numbers of relatively small diameter drops that are typically observed at higher precipitation rates under "warm rain" conditions. Displacements in the Z vs. Zdr parameter space are less well-defined since Z is affected by both drop concentration as well as by Dm. These results suggest that a line drawn orthogonally to the curves seen in the scattering model results should be useful in the differentiation of rain produced by predominantly "warm" vs. "cold" processes.

•Affiliations:
Kennedy and Rutledge: CSU Dept. of Atmospheric Science
Chandrasekar: CSU Dept. of Electrical and Computer Engineering

References available upon request.

Contact: pat@chill.colostate.edu

The CSU-CHILL Facility is sponsored by NSF cooperative agreement no: ATM 0735110