Snow Particle Size Distribution and Radar Properties Variability: Regime Dependence

Mark Kulie[1] and Claire Pettersen[2]

[1]Michigan Technological University, Houghton, MI, [2]University of Wisconsin-Madison, Madison, WI

*Contact Information:
mkulie@mtu.edu

Research Support Acknowledged from NASA PMM Grant NNX16AE21G and NASA GPM Ground Validation Support Team

I. Instrument Description

Precipitation Imaging Package (PIP; Figure 1): Optical disdrometer that measures particle size, fall speed, and tabulates particle size distribution (PSD). Particle effective density and precipitation rate are also derived.

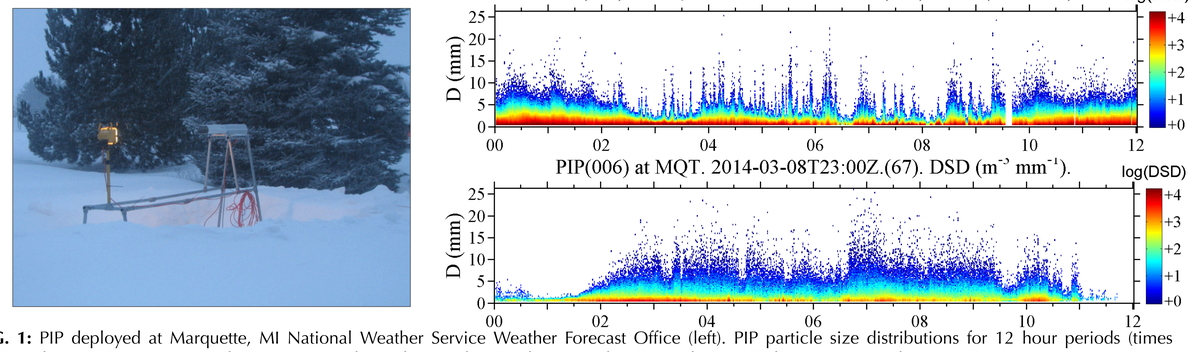


FIG. 1: PIP deployed at Marquette, MI National Weather Service Weather Forecast Office (left). PIP particle size distributions for 12 hour periods (times indicated are UTC) on 11 November 2014 (top right) and 8 March 2014 (bottom right). Coincident MRR observations are shown in Fig. 2.

Micro Rain Radar (MRR; Figure 2): Ka-band Frequency Modulated-Continuous Wave profiling radar that observes radar reflectivity, Doppler velocity, and spectral width.

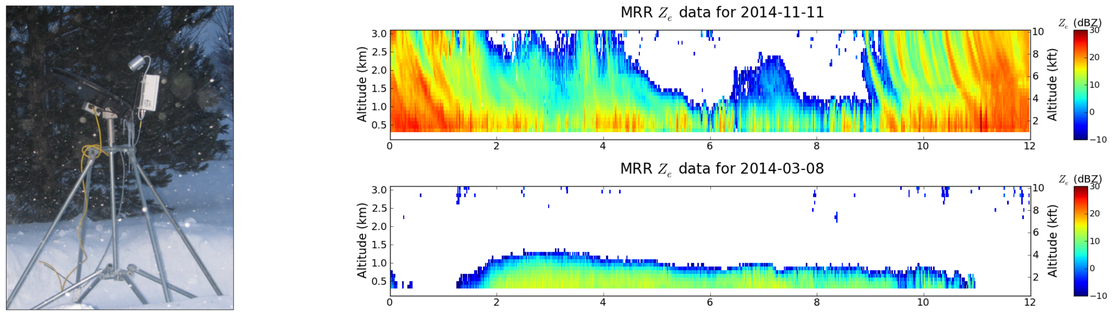


FIG. 2: MRR deployed at Marquette, MI National Weather Service Weather Forecast Office (left). MRR radar reflectivity profiles for 12 hour periods (times indicated are UTC) on 11 November 2014 (top right) and 8 March 2014 (bottom right). Coincident PIP observations are shown in Fig. 1.

II. Deployment Site

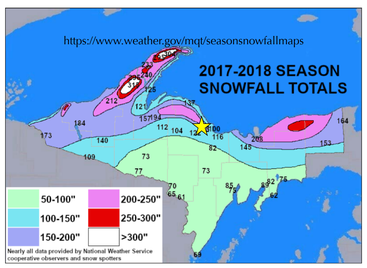


FIG. 3: MQT NWS instrument field (left and right). 2017-18 winter season regional snowfall accumulation for the MQT NWS county warning area (middle). The MQT NWS location is also indicated (yellow star).

Site: Marquette, MI National Weather Service Weather Forecast Office (MQT NWS)
- Significant annual snowfall amounts (Fig. 3)
- Different snowfall regimes contribute to annual snowfall
- Around-the-clock on-site staff
- Standard ancillary observations (e.g., NEXRAD, current weather, independent snowfall measurements)

PIP + MRR Operational Period: January 2014 – Present (almost 5 years near-continuous observations)

Common snowfall regimes:
- Synoptic/frontal snow
- Lake-effect convective snow
- Orographic
- Synoptic/frontal enhanced by orographic and/or lake-effect processes

Scientific Motivation: *Long-term* snow microphysics and profiling radar datasets for GPM algorithm development and validation activities.

III. Case Study: Snowfall Regime Variability

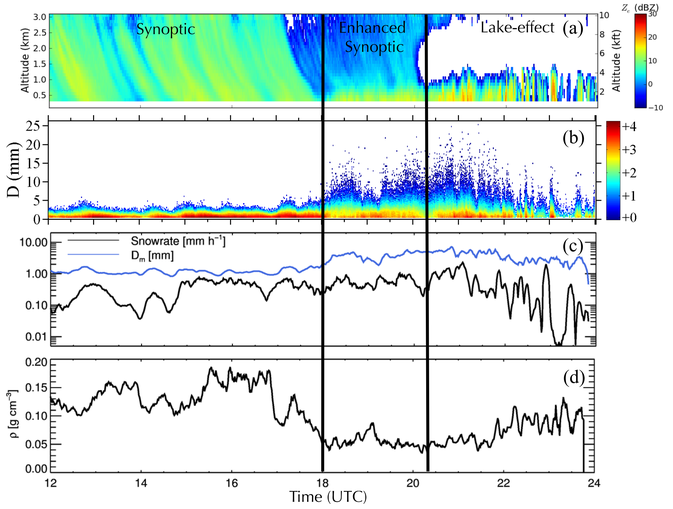


FIG. 4: (a) MRR radar reflectivity profiles, (b) PIP PSD, (c) PIP-derived snowfall rate and mass-median particle size, and (d) PIP-derived effective particle density for a 12-hour snowfall event on 13 December 2017.

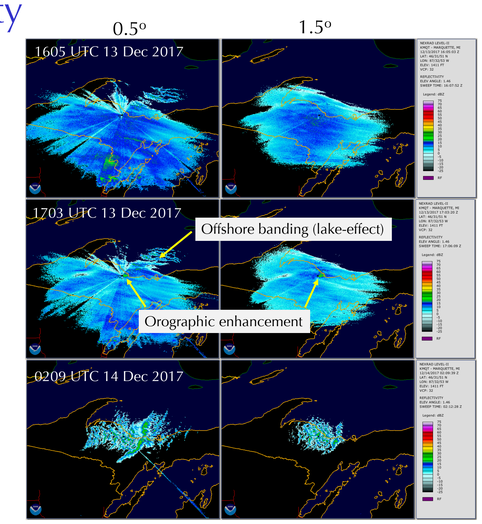
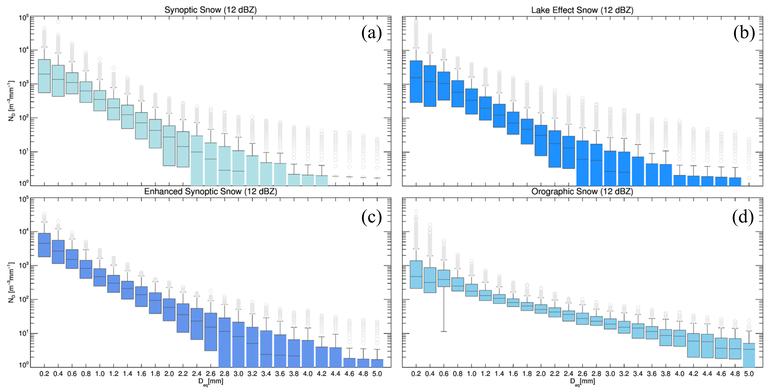


FIG. 5: NEXRAD 0.5° (left column) and 1.5° (right column) scans at 1605 UTC 13 December 2017 (top row), 1703 UTC 13 December 2017 (middle row), and 0209 UTC 14 December 2017 (bottom row).

IV. Snowfall Regime Variability: Multi-Year Analysis



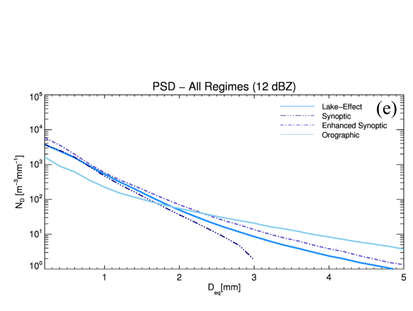


FIG. 6: Box-and-whisker PSD plots for (a) synoptic, (b) lake-effect, (c) enhanced synoptic, and (d) orographic snowfall events using 2014-2016 PIP observations. Mean PSD's for all snowfall regimes are shown in panel (e). All PSD's associated with MRR near-surface reflectivity ~12 dBZ are used. Snowfall events are categorized using MRR, NEXRAD, and surface meteorological, and MQT NWS area forecast discussion datasets.

Summary

I. Case Study
- Snowfall regime transitions = microphysics transitions
- PIP + MRR + NEXRAD combination useful to classify transitions
- Similar MRR Z_e -> Extremely different PSD and particle density
- Both small and large particle populations change drastically

II. Multi-Year Analysis
- Regime-dependent PSD differences
- Shallow snowfall prevalent
  - Lake-effect + orographic
  - Orographic
  - Low-level enhancement within deeper snowfall events
  - Features often observed < 1 km AGL
- Spaceborne radar/radiometer observational and QPE implications

III. Future Work
- Study GPM regime-dependent detection statistics and QPE differences versus ground-based datasets
- Regime-dependent PSD parameterization development
- Further partitioning possible based on environmental conditions

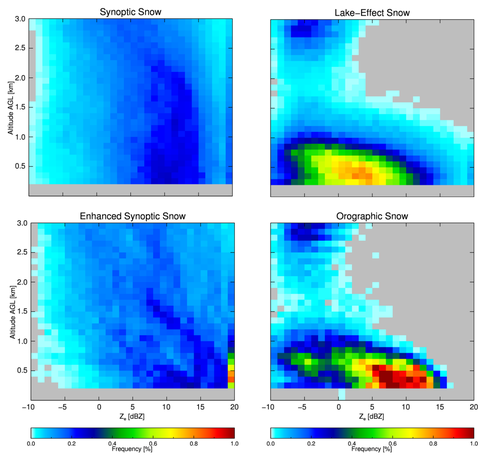


FIG. 7: MRR radar reflectivity relative frequency of occurrence statistics for the same snowfall regimes shown in Fig. 6.