Snowfall Modes Diagnosed from GV Observations: Implications for Satellite Snowfall Retrievals

Claire Pettersen[1] and Norm Wood[1]

With contributions from:
Mark Kulie[2], Walter Petersen[3], and Larry Bliven[4]

[1]University of Wisconsin-Madison, Space Science and Engineering Center, Madison, Wisconsin, claire.pettersen@ssec.wisc.edu
[2]Michigan Technological University, Houghton-Hancock, Michigan
[3]National Aeronautics and Space, Marshall Space Flight Center, Huntsville, Alabama
[4]National Aeronautics and Space, Goddard Space Flight Center/Wallops Flight Facility, Wallops Island, Virginia

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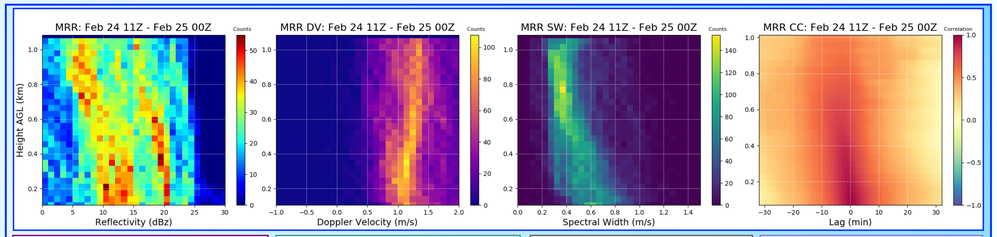
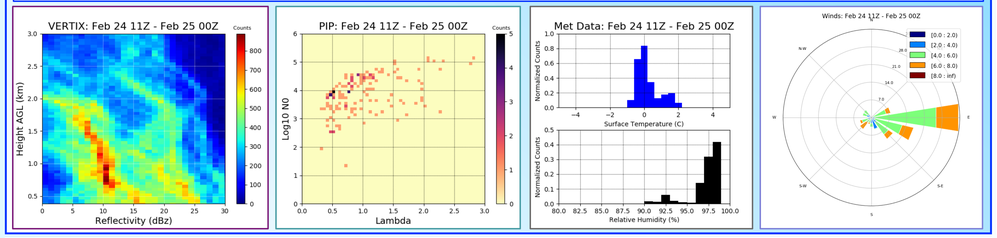
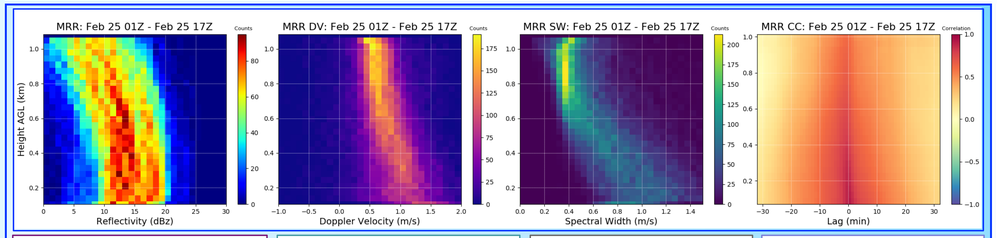
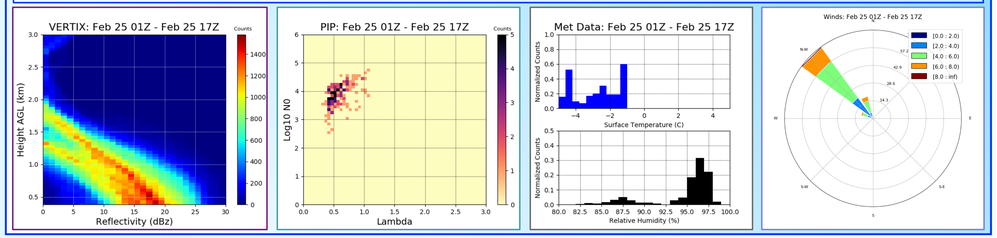
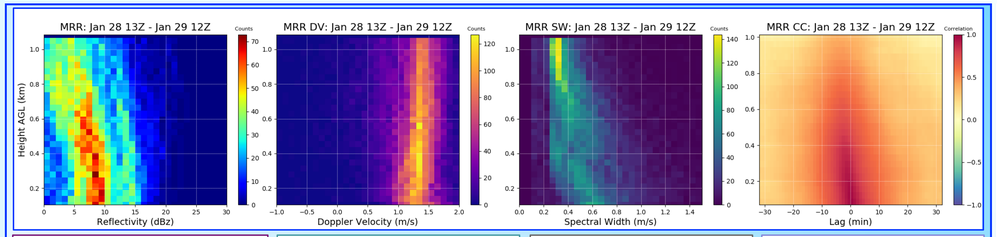
GCPEx: CARE Instrument Suite

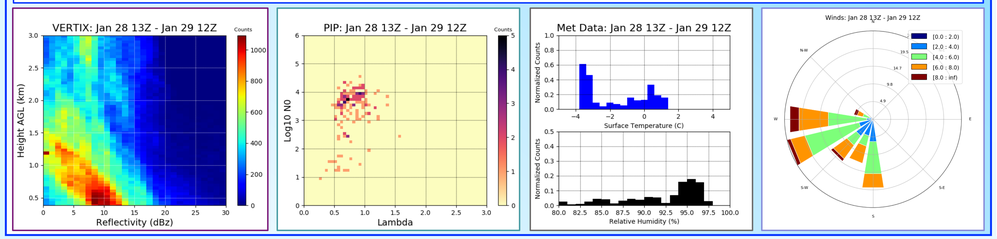












Cyclonic Case:

- Reflectivity very broad and weakly varying with height
  - Seemingly two modes seen in both **MRR** and the **VERTIX**
- Fairly high **Doppler velocities**
  - >1 m/s, slight decrease
- High **correlation** values (>0.7) between ±10 min up to 1 km
- **PIP** indicates a broad range of slope parameters and intercepts
- Warm **temperatures** at the surface and high **RH** consistent with a passage of a low-pressure system
- **Winds** from the E and moderate **wind speeds** also consistent with passage of low pressure system sitting E or SE of the site

Satellite-based radar retrievals are likely representative of process-modified surface conditions

Lake Effect Case:

- Reflectivity somewhat broad and increasing closer to the ground
  - Increase in reflectivity as a function of height is seen in both **MRR** and the **VERTIX**
- Lower **Doppler velocities** with some increase towards the surface
  - 0.5 m/s to >1.0 m/s
- High **correlation** values (>0.9) narrow (0 min) up to 1 km
- The **PIP** indicates small slope parameters (broad DSD)
  - Large particles
- Cold **temperatures** at the surface and high **RH** consistent with DGZ and aggregation in the BL
- **Winds** from the NW and moderate **wind speeds** consistent with lake effect snow production at the site

Satellite-based radar retrievals are not going to capture growth, however they should capture the along-track surface variability

Upper Level Case:

- Narrow range of reflectivities and invariant with height (**MRR**)
  - Increase in reflectivity as a function of height is seen in the **VERTIX**
- High **Doppler velocities** invariant with height
  - ~1.5 m/s
- High **correlation** values (>0.5) between ±10 min up to 1 km
- The **PIP** indicates mostly small slope parameters (broad DSD) with low intercept
- Broad range of **temperatures** at the surface and **RH**
- **Winds** from the W and SW and high **wind speeds** consistent with an upper level disturbance

Satellite-based radar retrievals may be representative of the process-modified surface conditions, albeit with lower CC and reflectivities near DPR limit

LPVEx: Jarvenpaa Instrument Suite

Cyclonic Case:

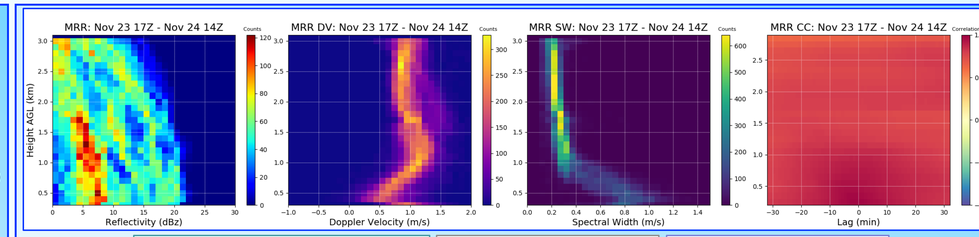
- **MRR** reflectivity very broad and invariant with height
- **Doppler velocities** decreasing in the BL
  - From 1 m/s to <0.5
- **Spectral width** increase in BL
- High **correlation** values (>0.8) throughout the entire height (3 km) and time (±30 min)
- **2DVD** has an exponential size distribution and many small particles
- Colder **temperatures** at the surface and lower **RH** indicating drier surface
- **Winds** from the NE and moderate **wind speeds** consistent with passage of low pressure system SE of the site

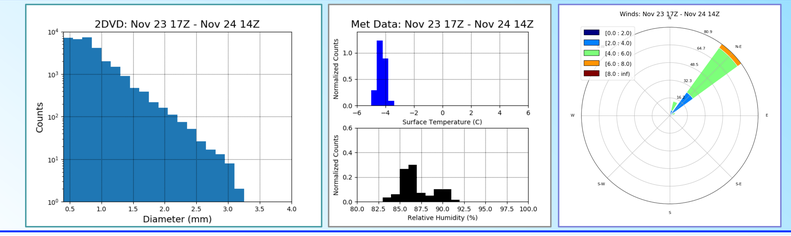
Satellite-based radar retrievals will have issues representing surface conditions as there are indications of evaporation in the BL

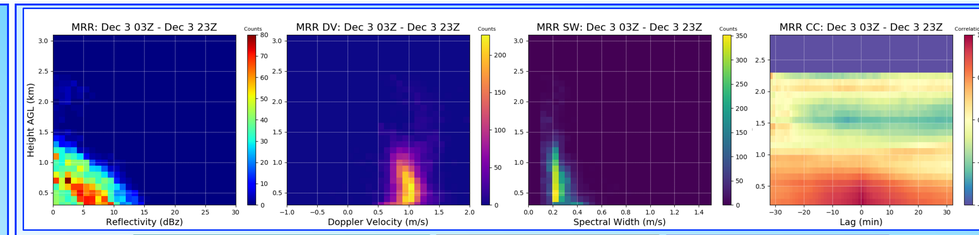
Shallow Pulsed Case:

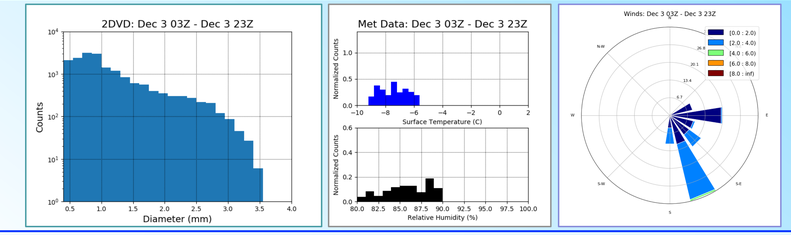
- Reflectivity narrow and increasing closer to the ground
  - Increase in reflectivity as a function of height is seen in the **MRR**
- Invariant **Doppler velocities**
  - ~1.0 m/s
- Narrow **spectral width**
- The **Correlation** values are >0.8 up to 700 m and ±20 min
- The **2DVD** indicates presence of large particle and fewer small particles (not exponential)
- Very cold **temperatures** at the surface and higher **RH** consistent with DGZ in the BL
- **Winds** from the SE and E, low **wind speeds** consistent with possible ocean-effect snow

Satellite-based radar retrievals are not going to see this event as it is both too shallow (<1 km) and too light (<12 dBZ)









Microphysical properties from GV observations

- **Radar profiles show characteristics that tie to differences in meteorological forcing, which seem consistent at different sites**
- **Microphysical retrievals on observations will allow us to relate radar classifications to the underlying microphysical properties**
- **Should allow for improved *a priori* assumptions in radar-based retrieval algorithms**

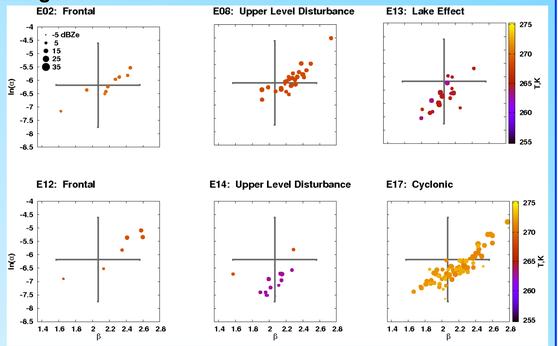
$$m(D) = \alpha D^{\beta}$$

$$A_p(D) = \gamma D^{\sigma}$$

Remote sensing techniques like optimal estimation can be used to 'retrieve' microphysical properties from near-surface observations.

For snow:

- $m(D)$:
- N(D) (disdrometer)
- V(D) (disdrometer)
- Z_e at range ~0 (radar)
- Precipitation rate (e.g., Pluvio)



References:

- Wood, N. et al., : Microphysical Constraints on Millimeter-Wavelength Scattering Properties of Snow Particles, J. Appl. Meteor. Climatol., 54, 909–931, 2015, doi:10.1175/JAMC-D-14-0137.1
- Skofronick-Jackson, G. et al.: Global Precipitation Measurement Cold Season Precipitation Experiment (GCPEX): For Measurement's Sake, Let It Snow, BAMS, 96.10, 1719-1741, 2015: doi: 10.1175/BAMS-D-13-00262.1
- Kulie, M. and Bennartz, R.: Utilizing Spaceborne Radars to Retrieve Dry Snowfall, J. Appl. Meteor. Climatol., 48, 2564–2580, 2009, doi:10.1175/2009JAMC2193.1
- Maahn, M. and Kollias, P.: Improved Micro Rain Radar snow measurements using Doppler spectra post-processing, Atmos. Meas. Tech., 5, 2661–2673, 2012, doi:10.5194/amt-5-2661-2012.