

Enhancing our Understanding of Precipitation Modes with Ground-Based Observations

Claire Pettersen and Mark Kulie

NWS Marquette: Robin Turner, Mike Dutter, Todd Kluber, Tim Akom, Gwen Akom

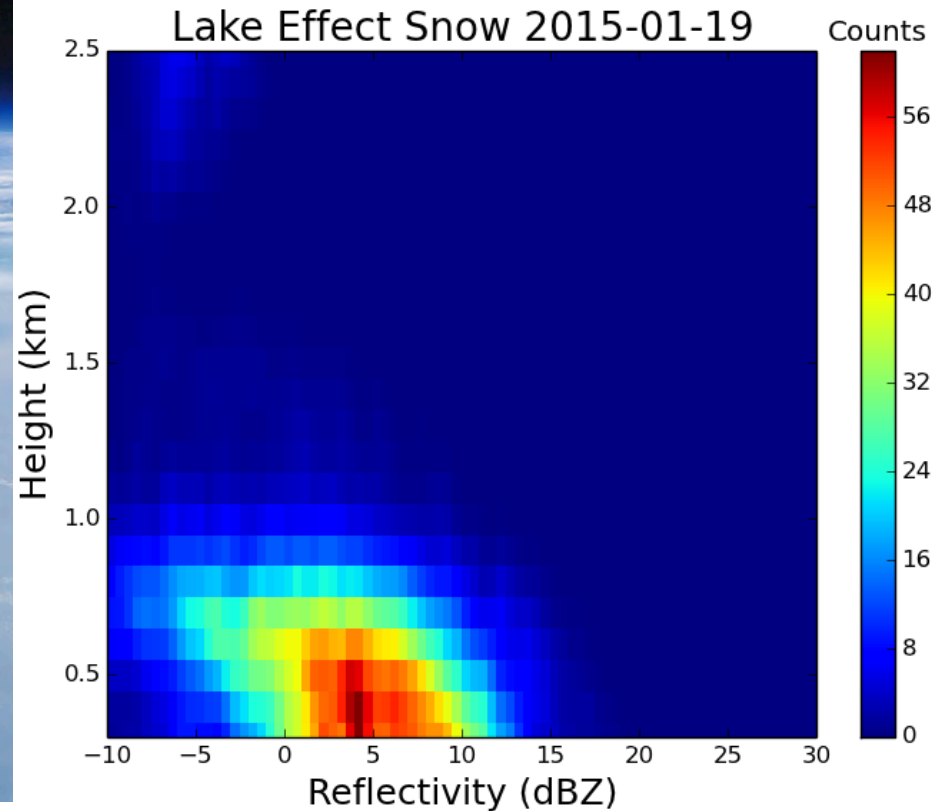
NASA Wallops: Walt Petersen, Larry Bliven, David Wolff

University of Wisconsin: Aronne Merrelli, Sam Tushaus

Motivation: GPM – Shallow Precipitation

NASA NIP – Mark Kulie, PI

Global Precipitation Measurement
Core Observatory



Motivation: GPM – Shallow Precipitation

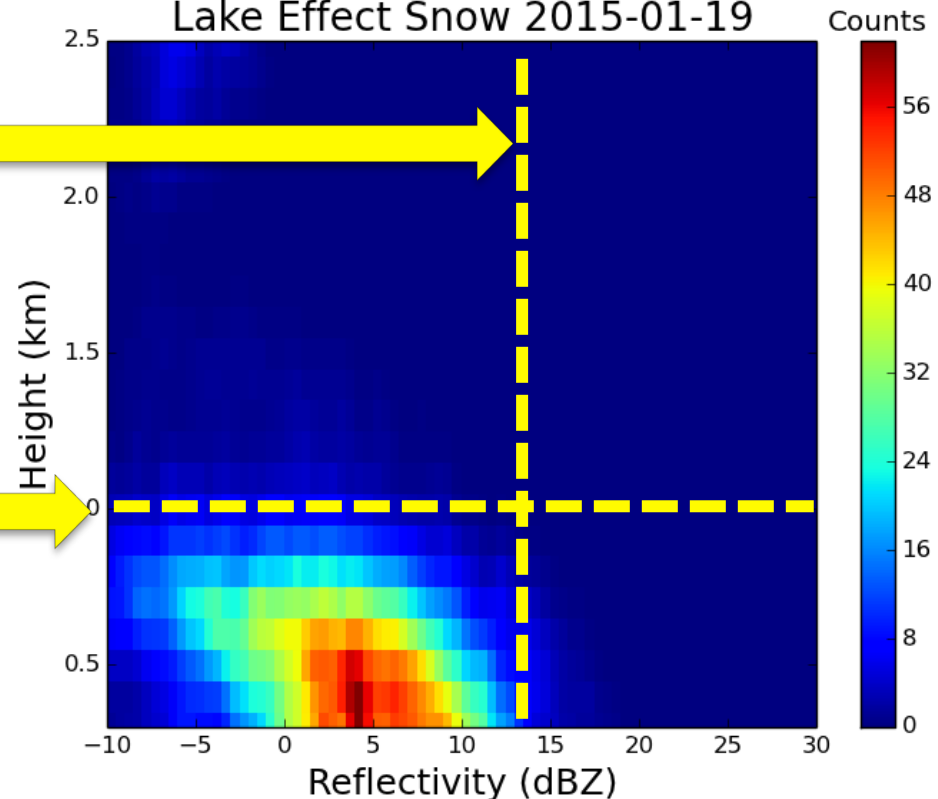
Satellite Detection Limits

~12dBZ radar limit

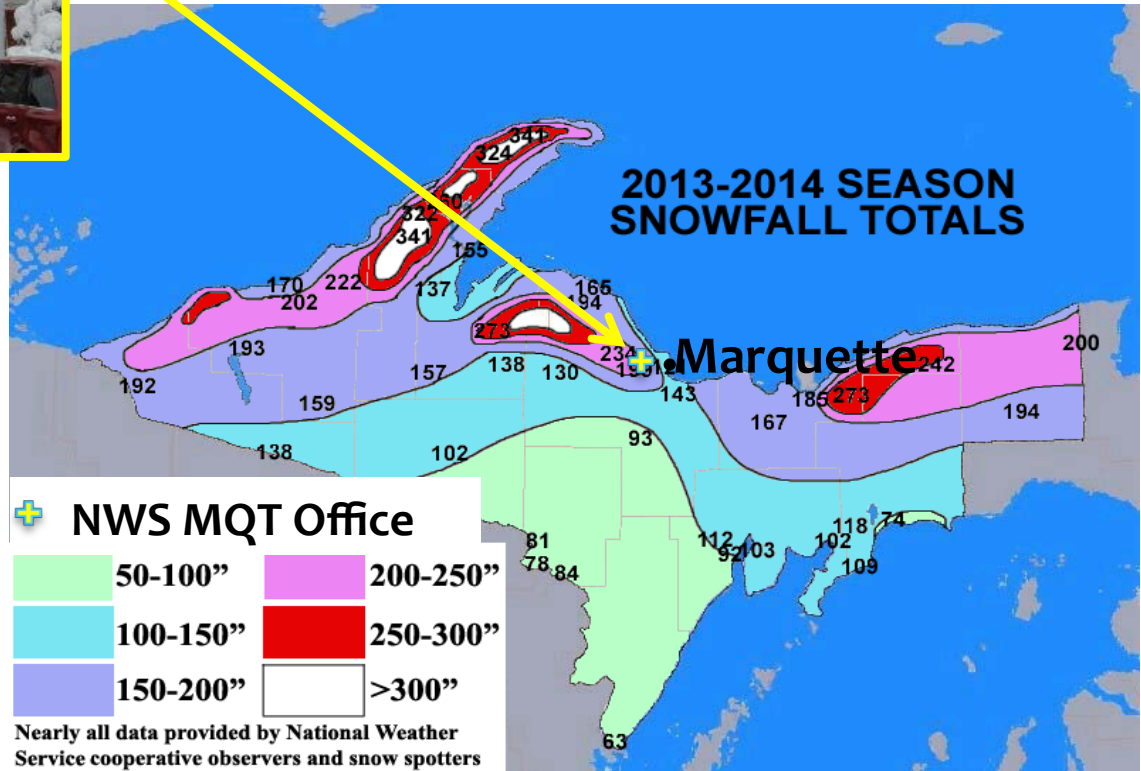
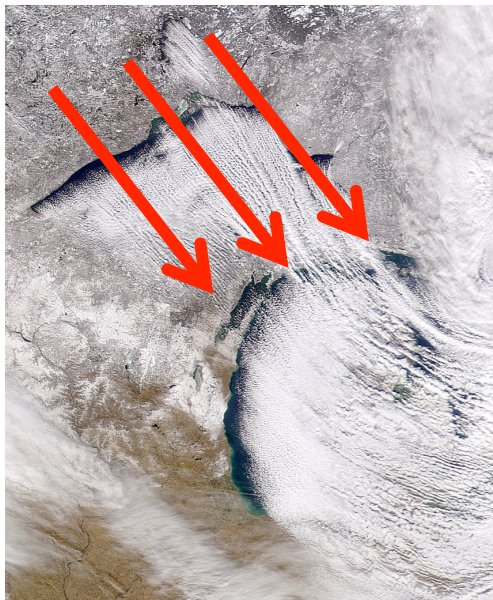
~1km height limit

Science/Climate Impacts

Lake Effect Snow 2015-01-19



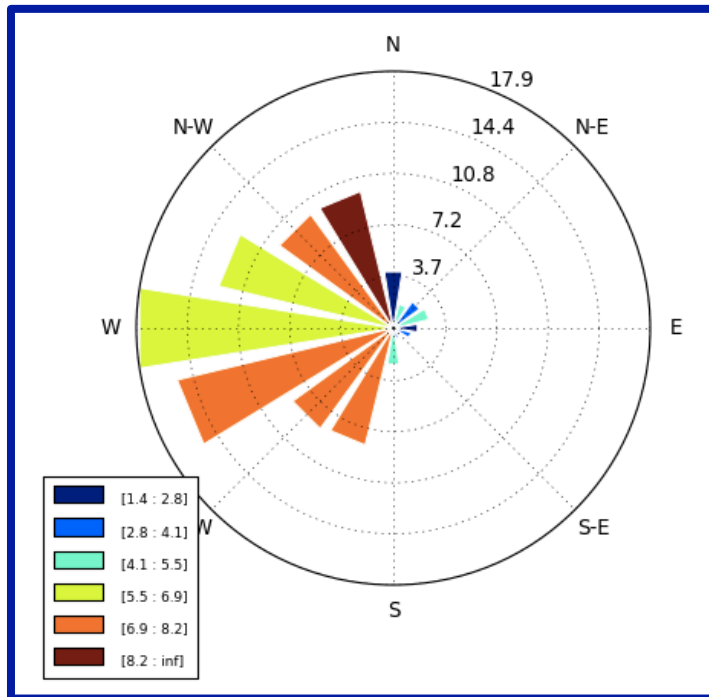
Motivation: Why Marquette?



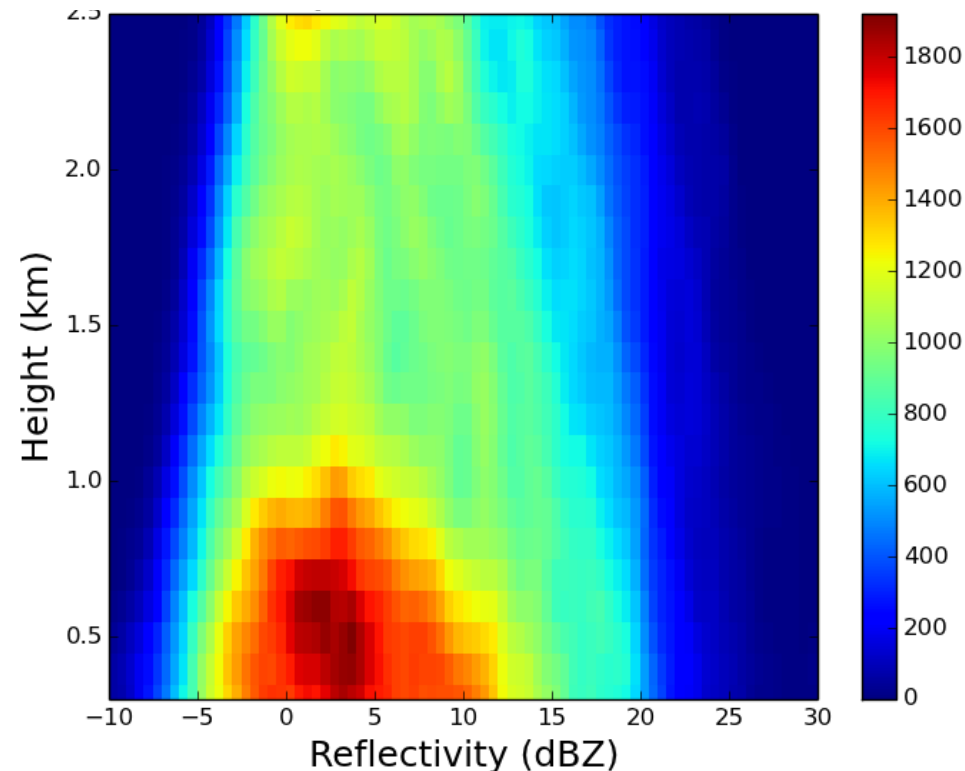
Marquette Winters 2014 – 2016

Surface Temperature < 2°C

Composite Winter Wind Data



Composite Winter Snow CFAD



Instrumentation and Facility

MicroRain Radar (MRR):

- * 24 GHz Frequency Modulated Continuous Wave Radar
- * Doppler spectra
- * Optimized for snow using Maahn *et al.*, algorithm



Precipitation Imaging Package (PIP):

- * Camera and light coupled for imaging falling precipitation
- * Captures ~400 images/second



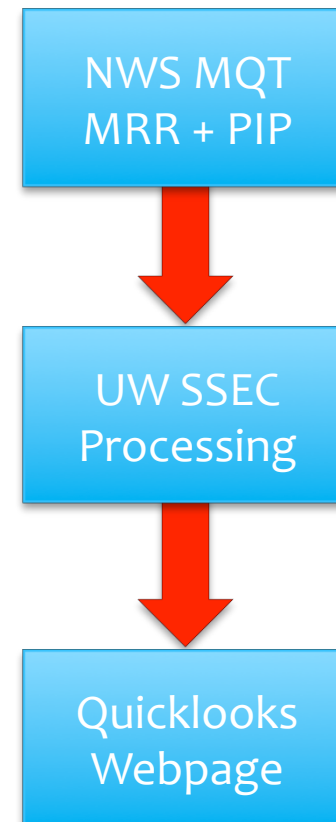
Marquette, Michigan NWS Office:

- * Information and support from SOO and forecasters
- * Automated weather observations Davis
- * Radar data from the NEXRAD
- * Snowfall accumulations from observers



Data Processing: MRR and PIP

- * Data backed up using Google Drive
- * Data pulled daily by UW – SSEC at Day+1 at 0200 UTC
- * MRR raw data is processed using tools created in house (Pettersen *et al.*) and optimized for snow (Maahn *et al.*)
- * MRR processed data is used to create figures of reflectivity and fall velocities
- * PIP data is processed locally and final DSDs and plots are pulled from MQT
- * MRR and PIP plots are uploaded to the Quicklooks Website



Data Processing: Online Browser

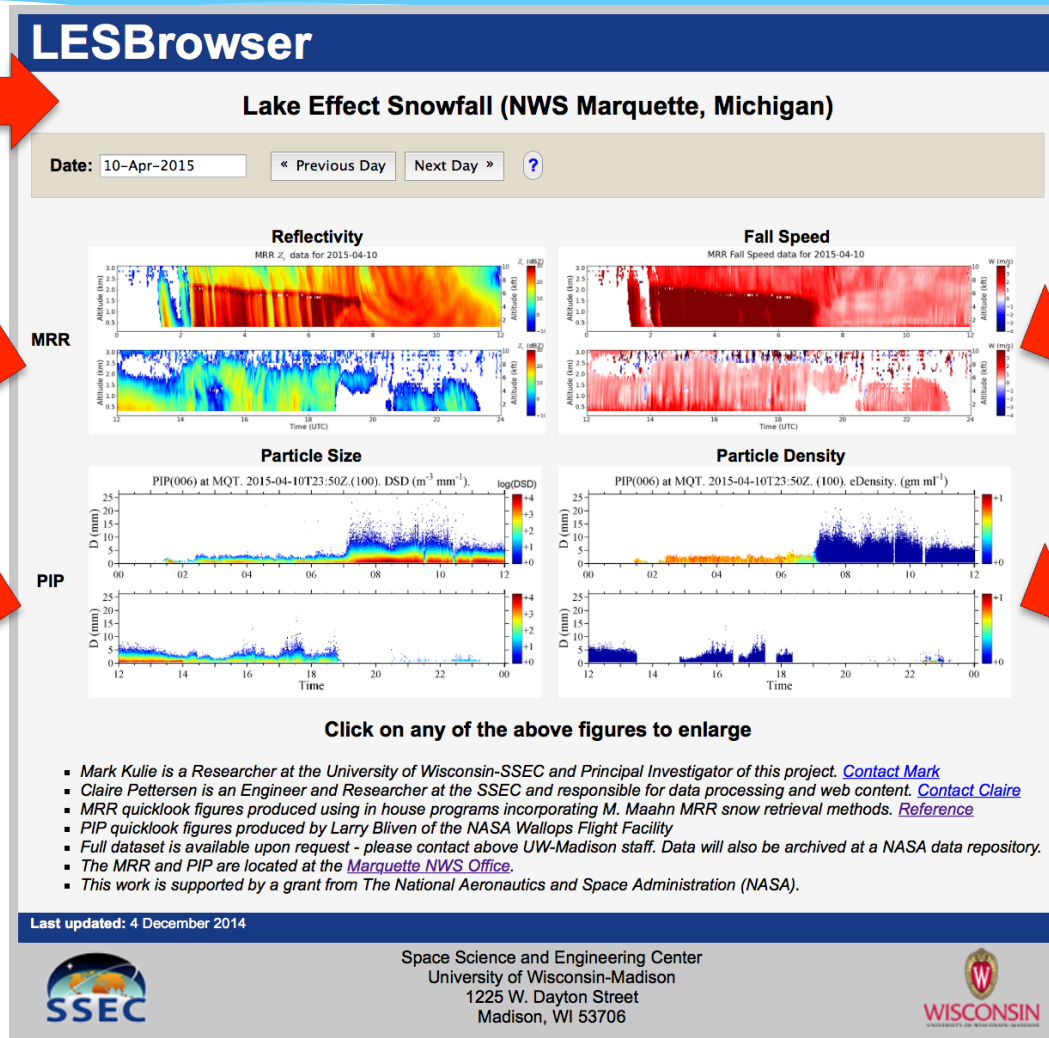
http://www.ssec.wisc.edu/lake_effect/mqt/

2+ years of data from the site to easily access

Time/Height plot of MRR reflectivity

Time/Diameter plot of PIP particle concentration

All data is pulled from site daily (0200UTC+1), processed, and uploaded to website

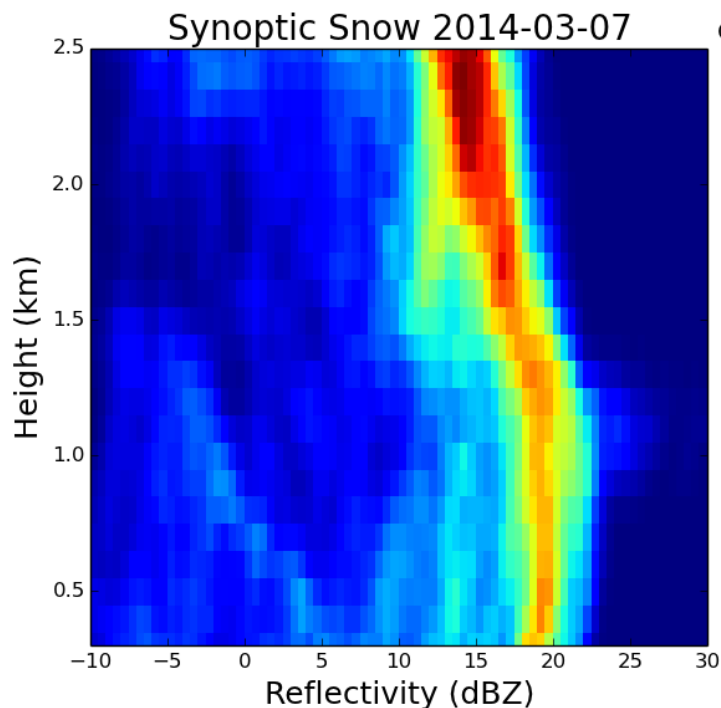
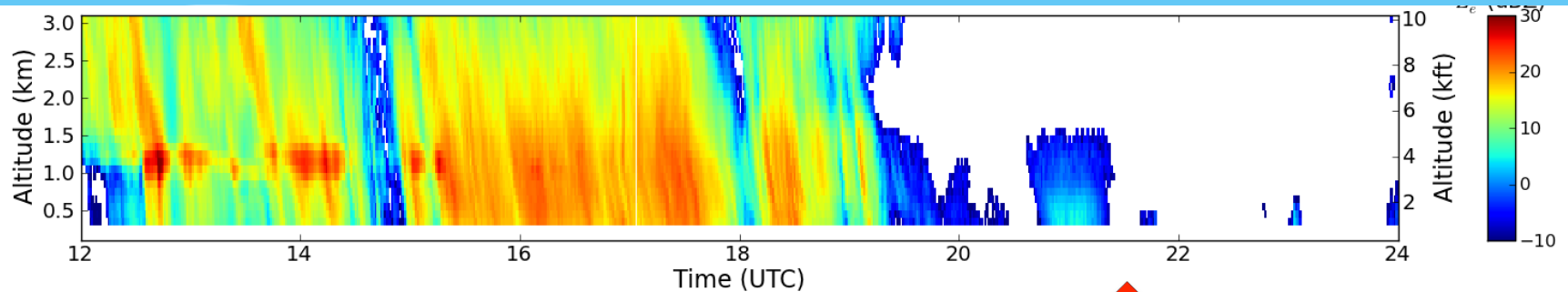


Time/Height plot of MRR measured fall speeds

Time/Diameter plot of PIP particle densities

MRR "real time" capabilities are in development for operational use (processed MRR every 15 min)

Data Analysis: MRR CFADs

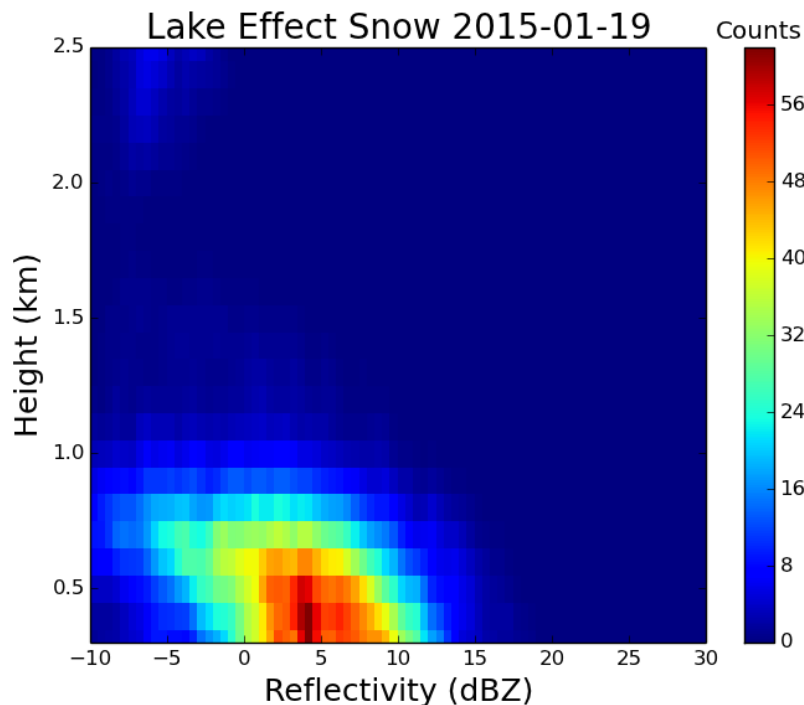
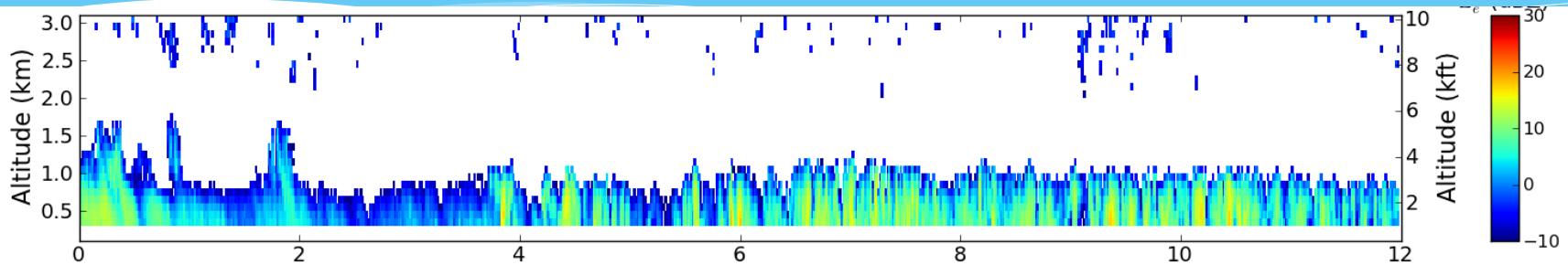


**Synoptic
Example
March 7, 2014**

- Deep Snow
- Narrow range around
 - 20dBZ
- Evidence of fall streaks

CFAD = Contoured Frequency by Altitude Diagram
Two-Dimensional Histogram (statistics)

Data Analysis: MRR CFADs



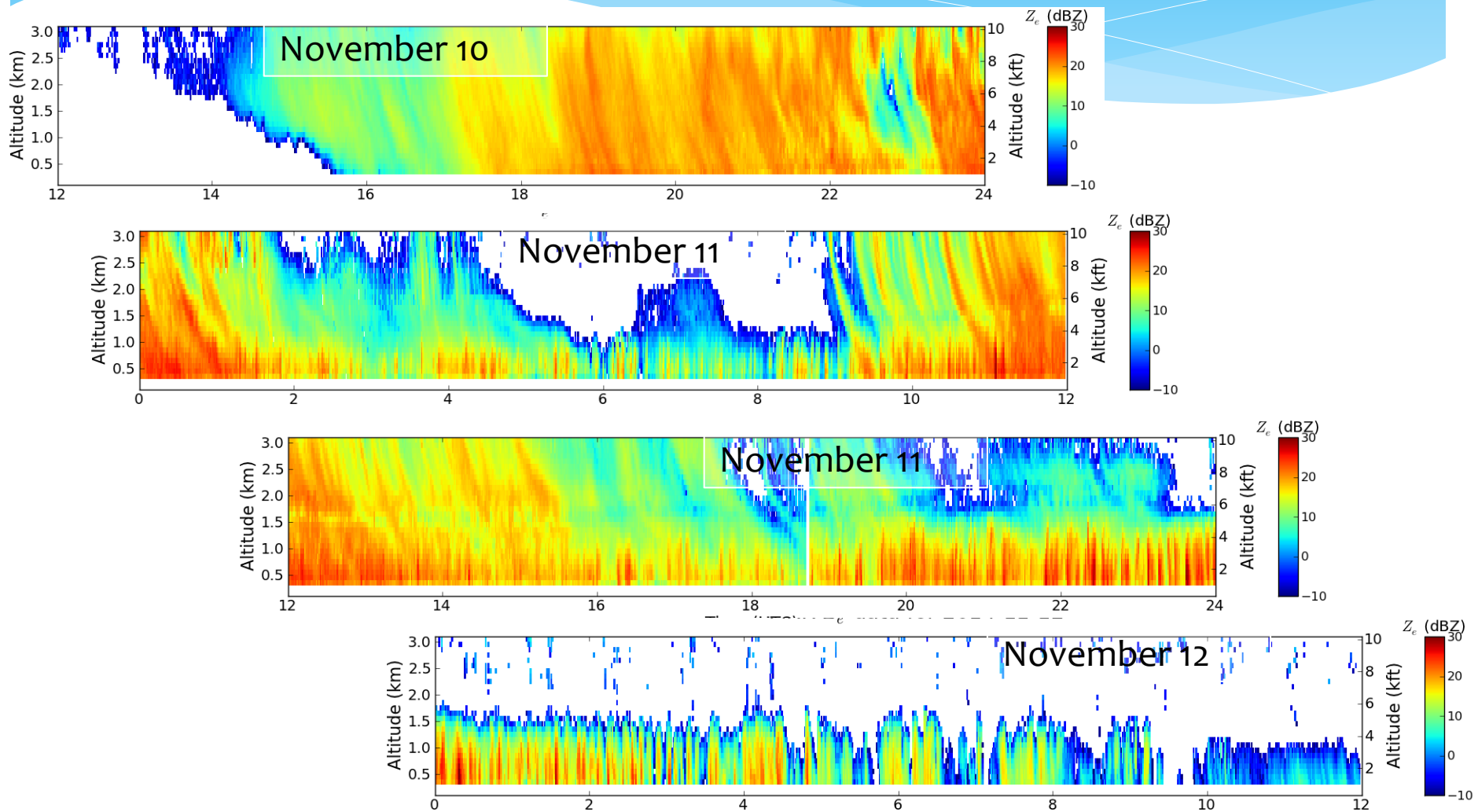
**LES
Example
January 19, 2015**

- Shallow Snow
- Mostly from 0 to 12dBZ
- Evidence of growth
 - As a function of height

CFAD = Contoured Frequency by Altitude Diagram
Two-Dimensional Histogram (statistics)

Data Analysis: MRR

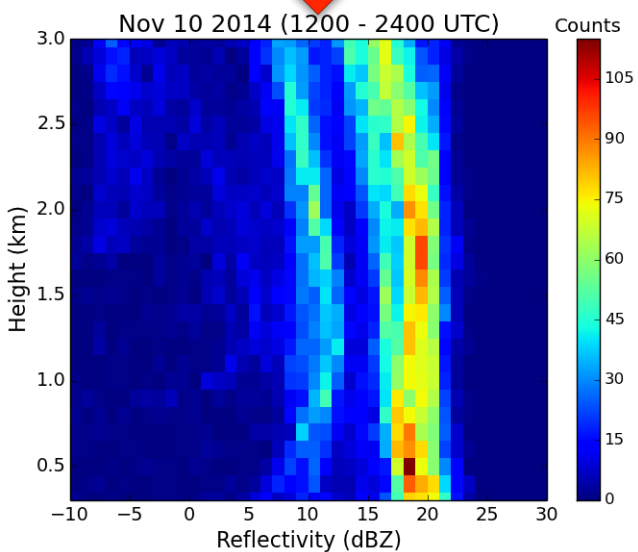
November 10 – 12, 2014 Storm



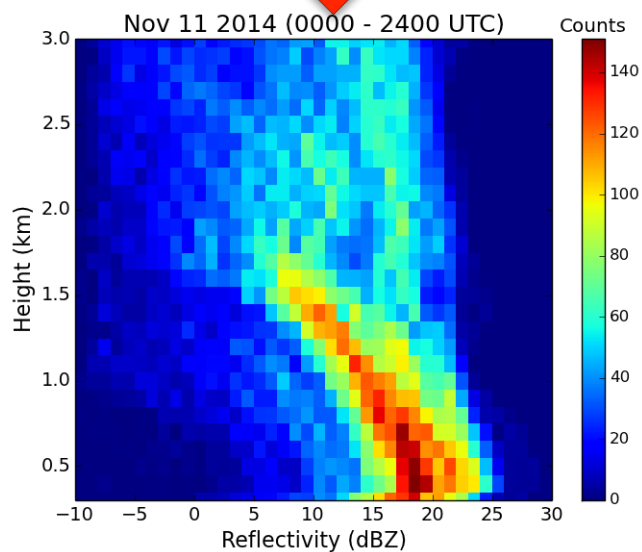
Data Analysis: MRR

November 10 – 12, 2014 Storm

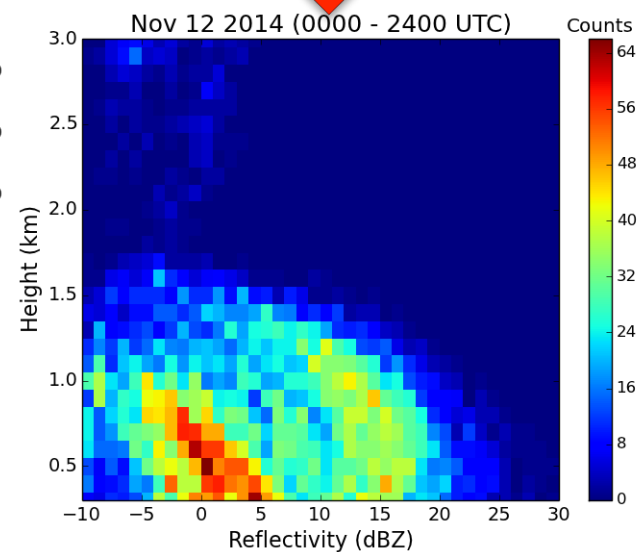
November 10
Synoptic



November 11
Embedded
LES



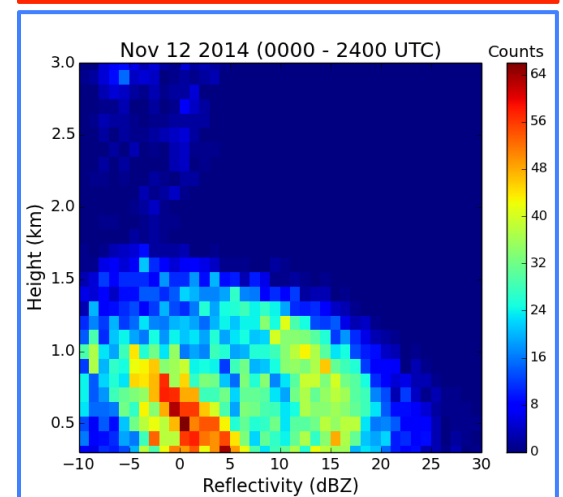
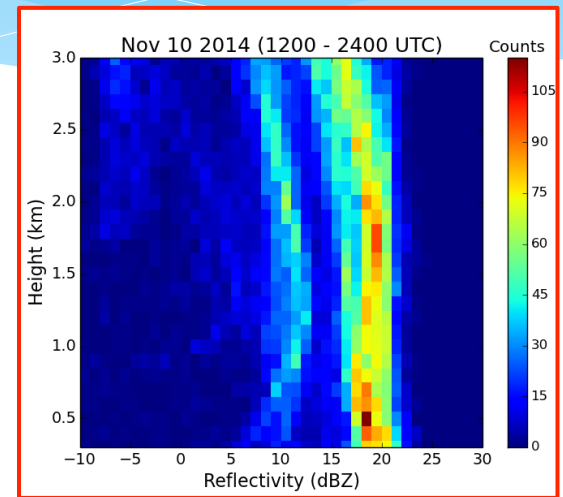
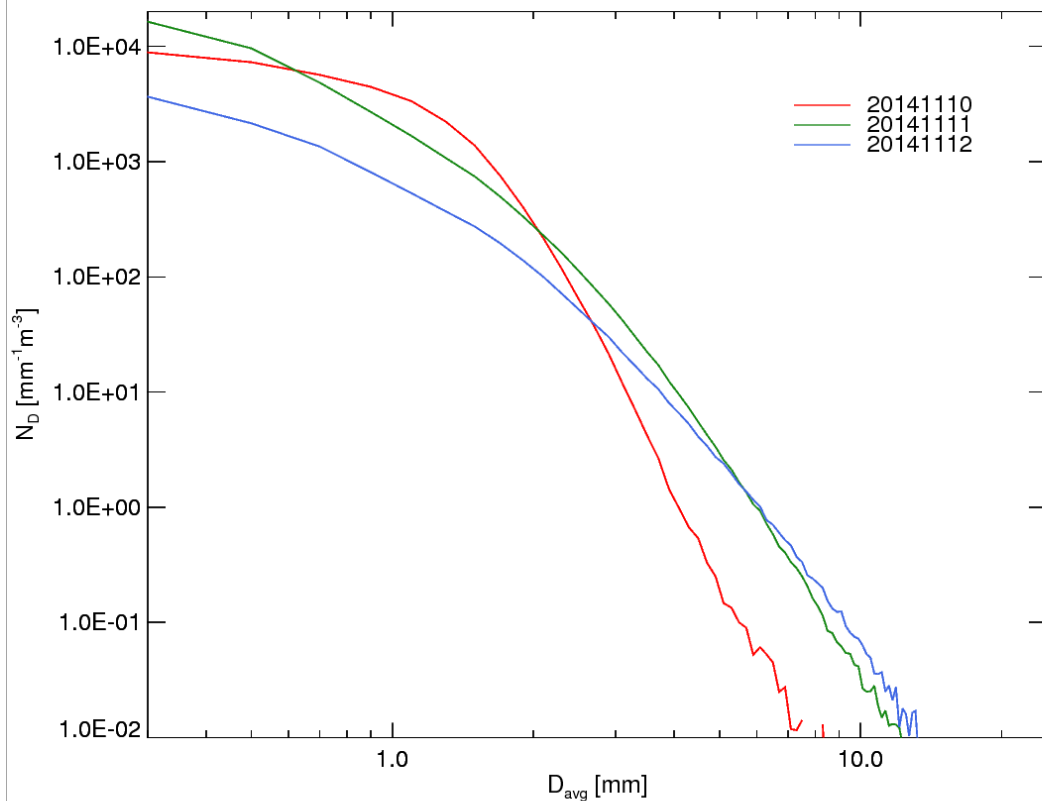
November 12
LES



Data Analysis: MRR and PIP

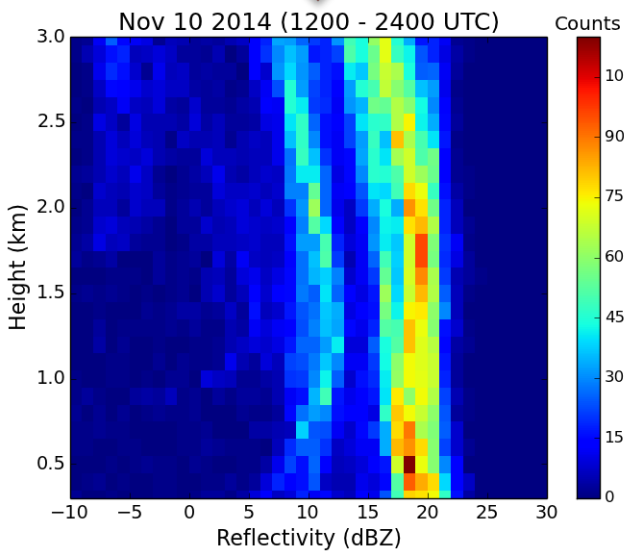
November 10 – 12, 2014 Storm

PIP: Particle Size Distribution

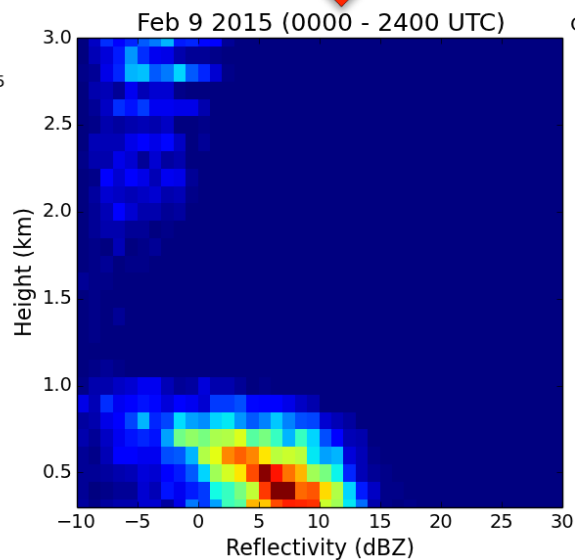


Data Analysis: MRR CFADs Snow “Modes”

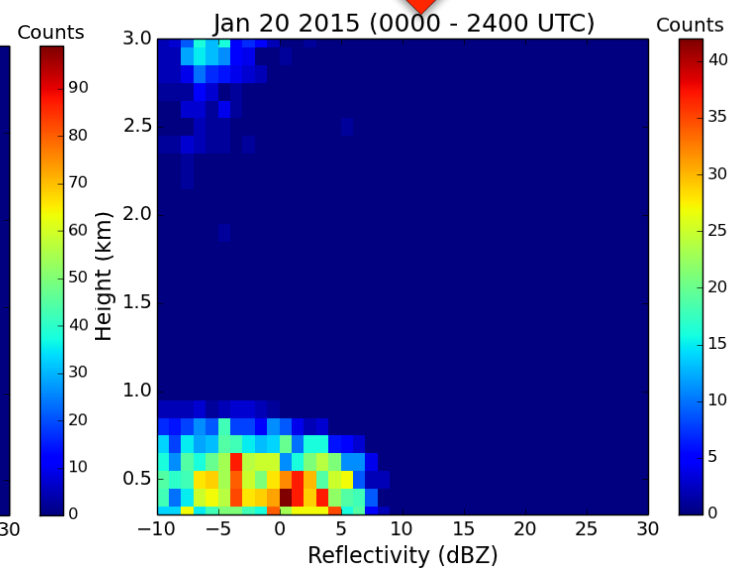
Synoptic
Snow



Lake Effect
Snow

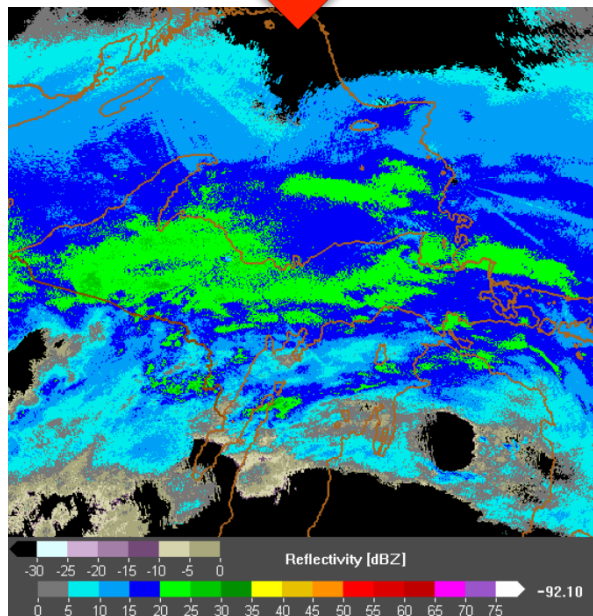


Orographic
Snow

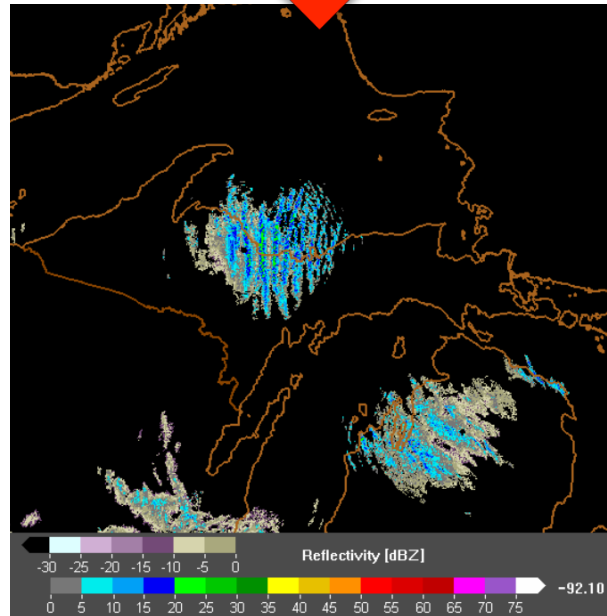


Data Analysis: Snow Modes

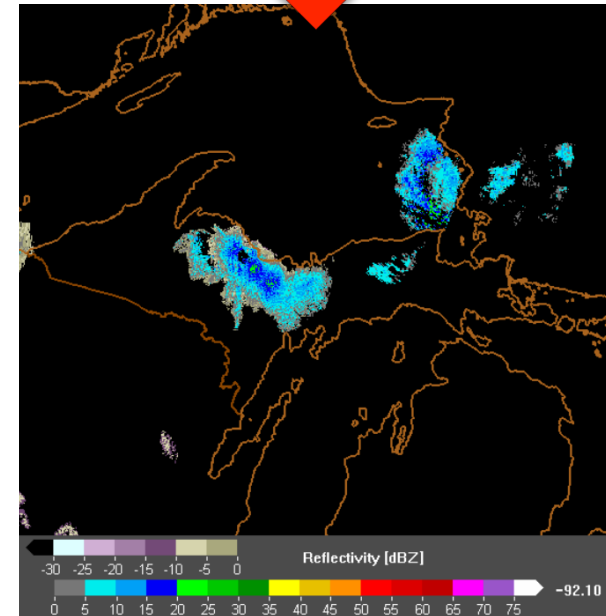
Synoptic
Snow



Lake Effect
Snow



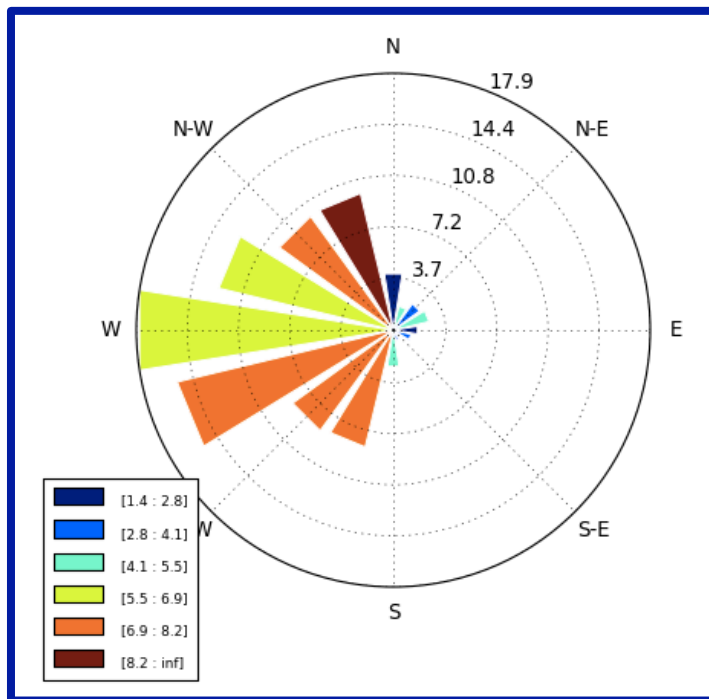
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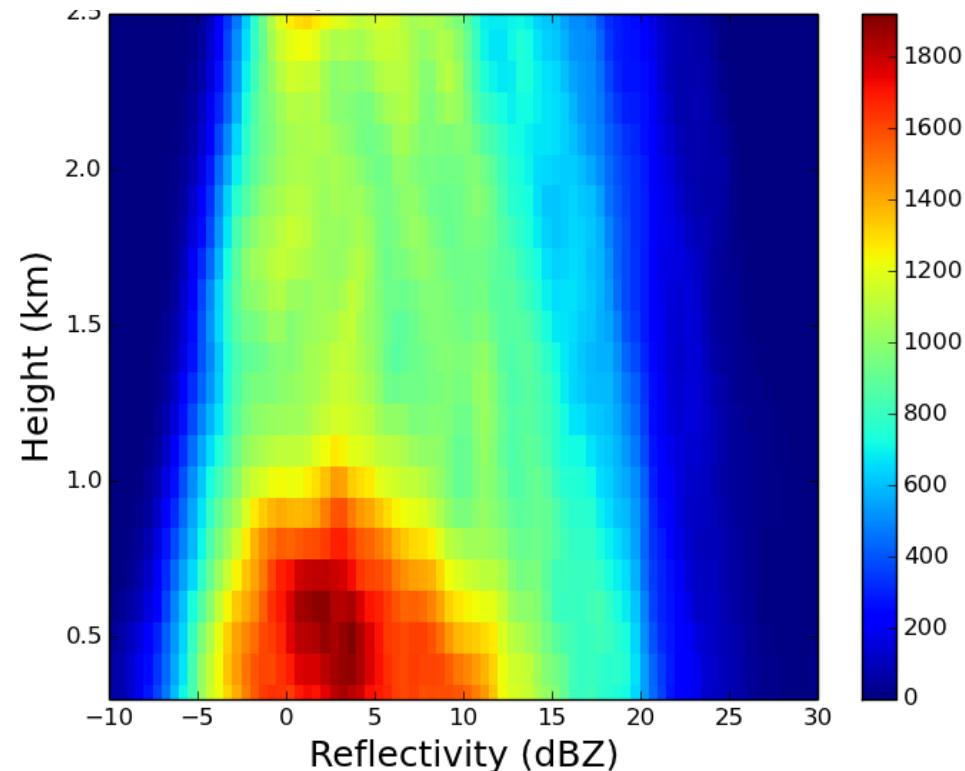
Data Analysis: Marquette Winters 2014 – 2016

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Composite Winter Snow CFAD



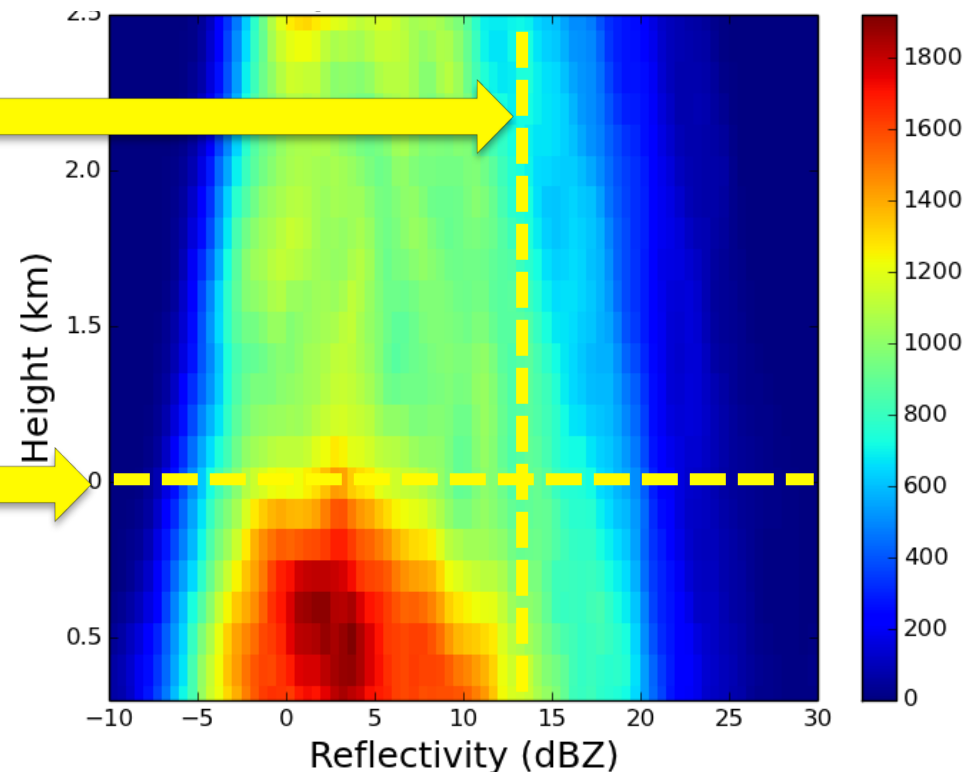
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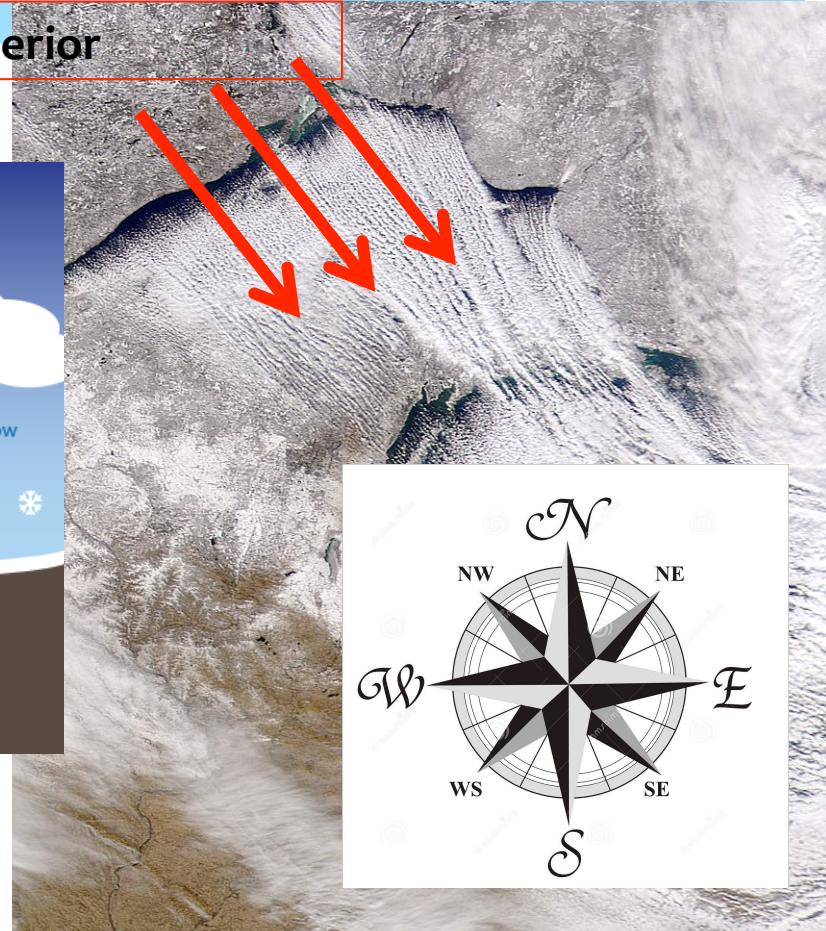
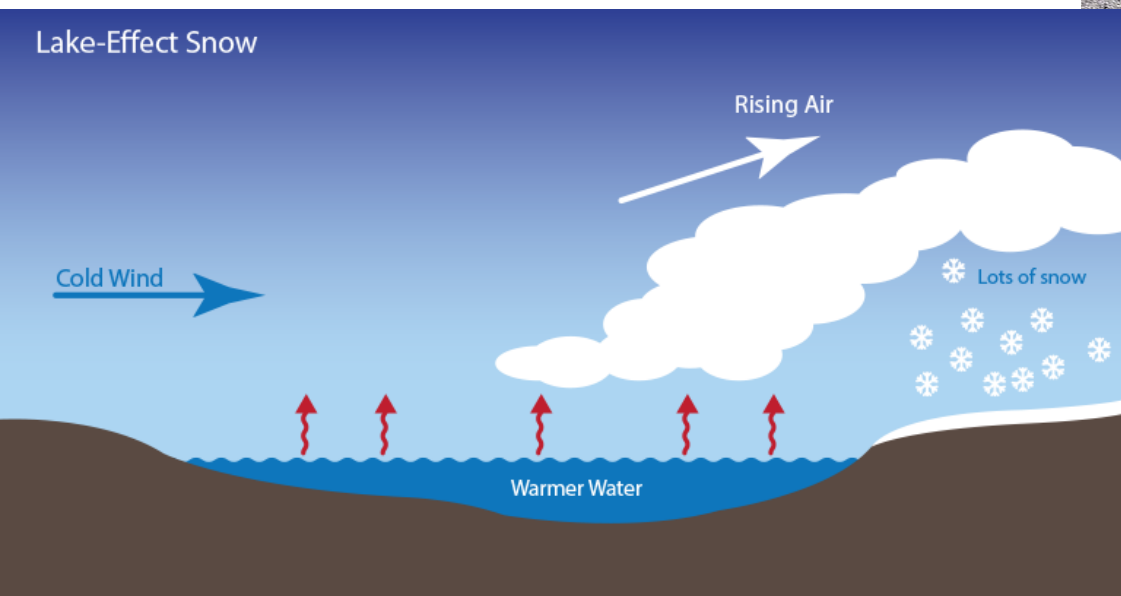
Composite Winter Data



Data Analysis: MRR, PIP, and NWS Instruments

Wind out of the NW is across longest fetch of Superior

Lake-Effect Snow



NASA JPL

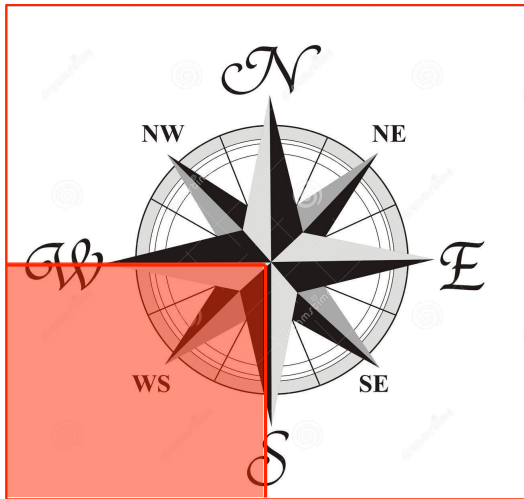
Lake Effect Snow –
Mechanism depends on wind direction

NASA Real Earth

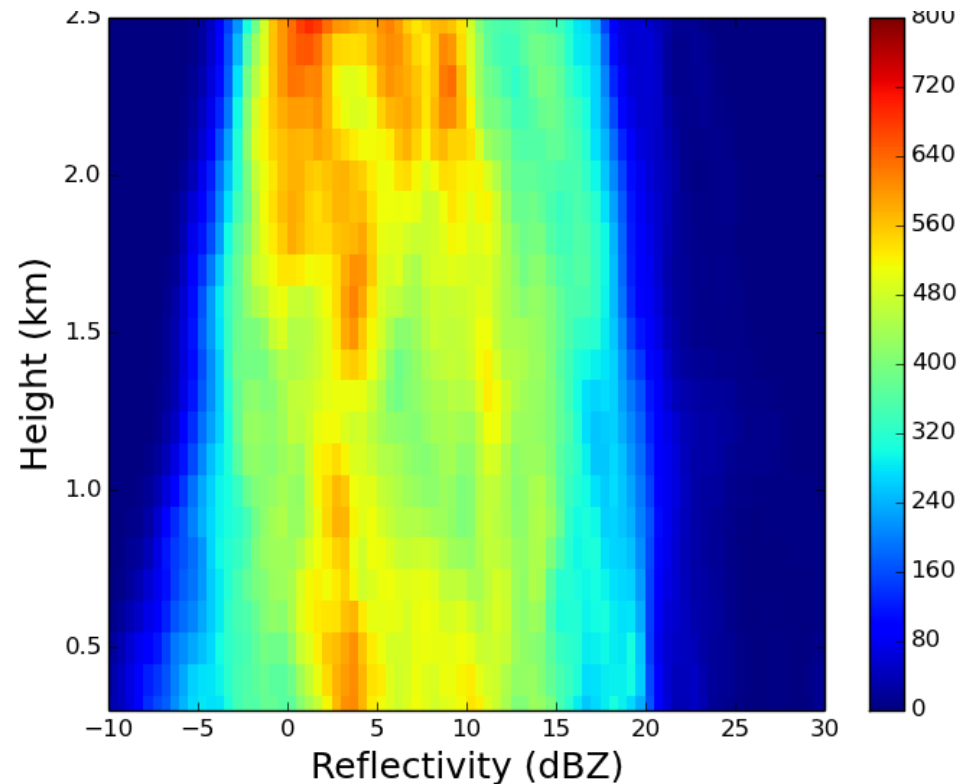
Data Analysis: MRR, PIP, and NWS Instruments

Surface Temperature $< 2^{\circ}\text{C}$

Southwesterly Winter Wind



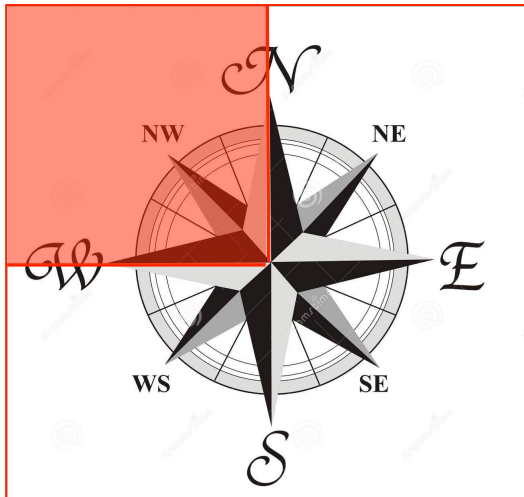
SW Wind Winter Snow CFAD



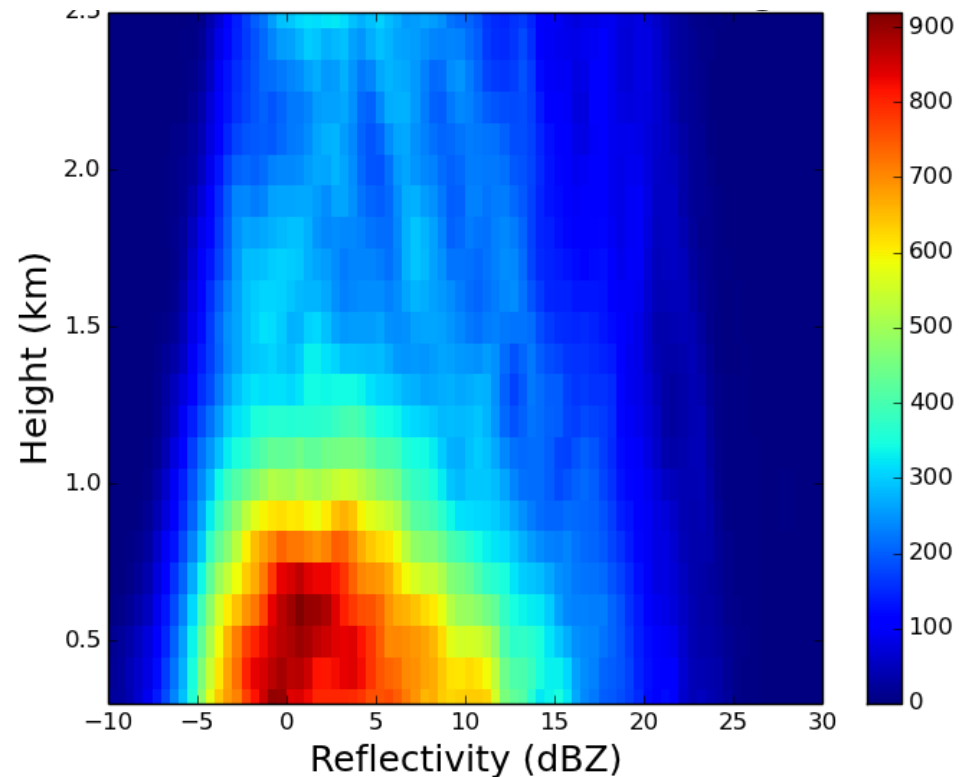
Data Analysis: MRR, PIP, and NWS Instruments

Surface Temperature < 2°C

Northwesterly Winter Wind



NW Wind Winter Snow CFAD



Thank You

