Vertical Radar Data and Precipitation Imaging for Winter Weather Events in Upper Michigan

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Research Overview

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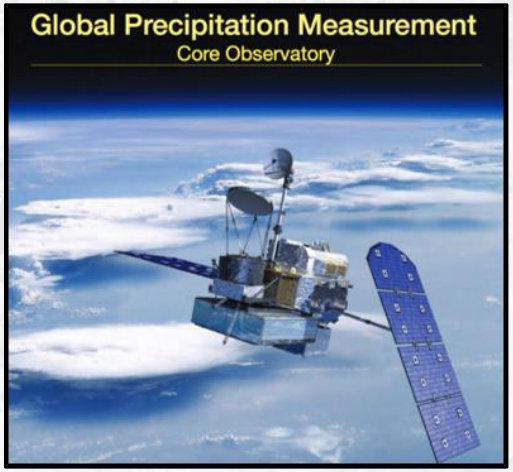
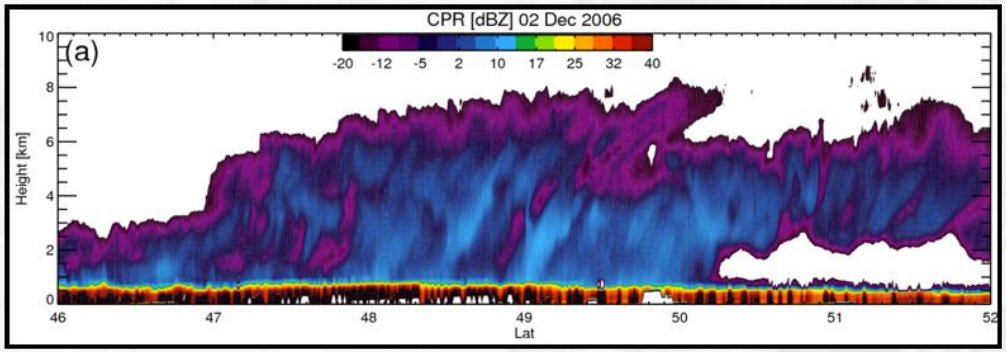
- **Two instruments deployed at NWS Marquette in January 2014:**
  - Micro Rain Radar (MRR)
  - Precipitation Imaging Package (PIP)
- **NASA Spaceborne radar support**
  - CloudSat
  - Global Precipitation Measurement
- **Reflectivity profiles sub 1-km**
  - Ground clutter affects lowest few data bins from spaceborne radar
- **Microphysics observations**
  - Differences between snowfall types?
  - Spaceborne detection difficulties?

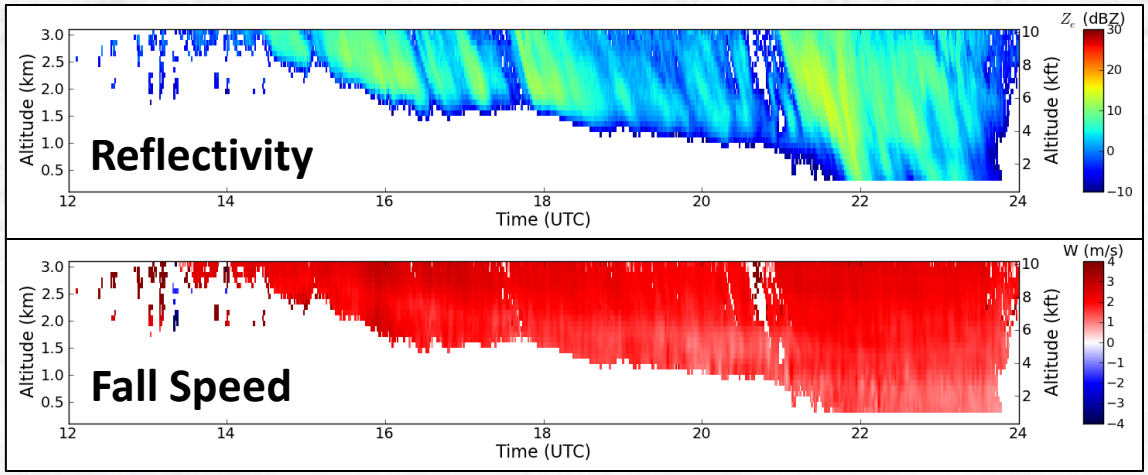




Micro Rain Radar (MRR)

- Vertically pointing Ka-Band Radar
- 1.24cm wavelength
- 28 range gates from 300 to 3000m

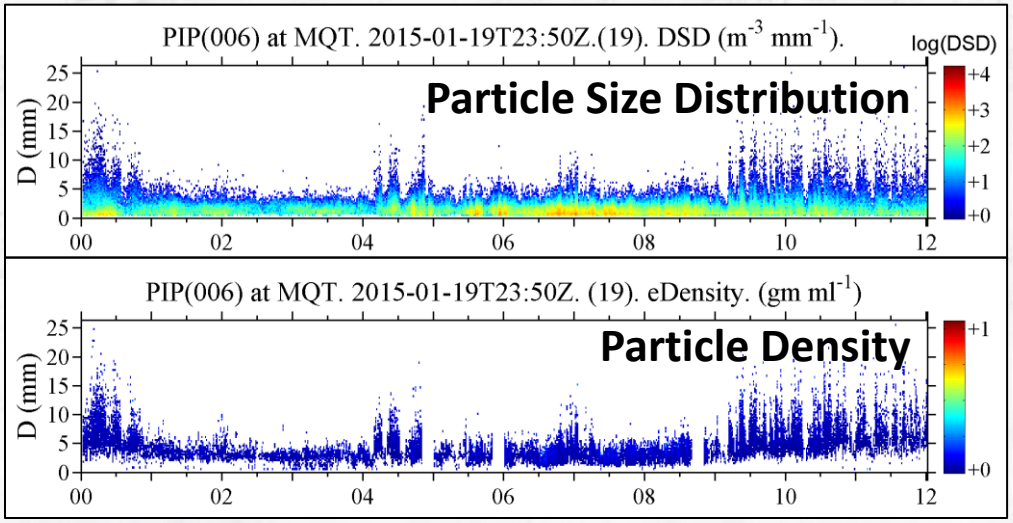
www.ssec.wisc.edu/lake_effect/mqt/

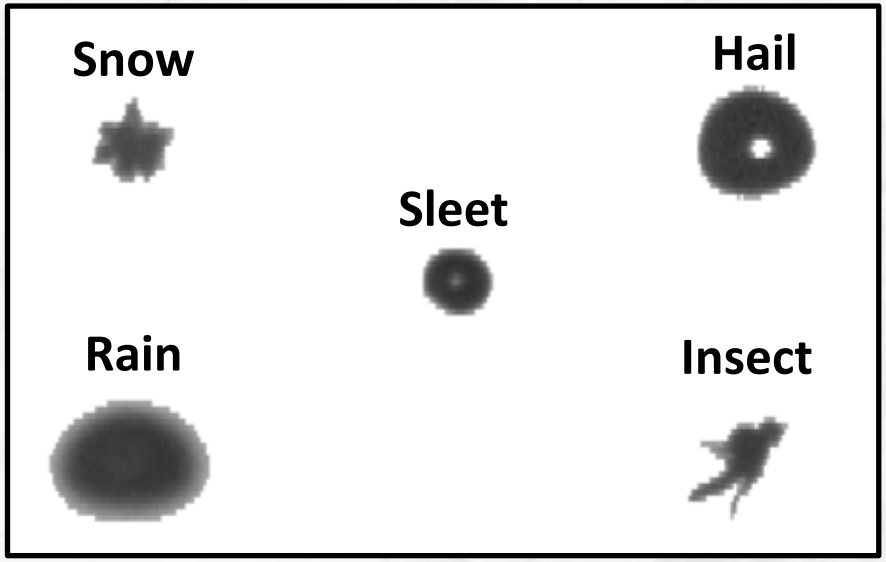


Precipitation Imaging Package (PIP)

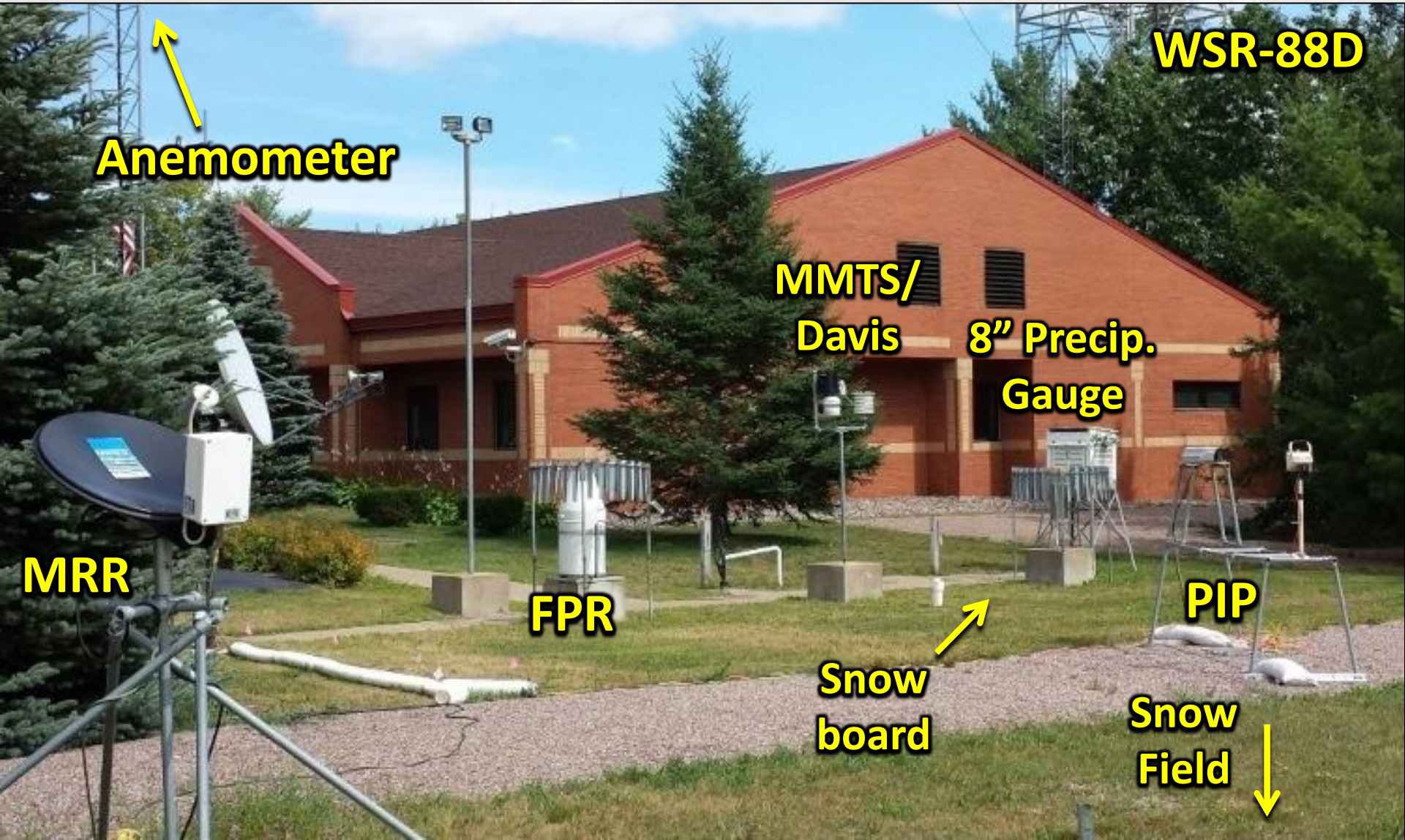
- Optical cloud microphysics instrument
- High-speed photography (380 frames/sec)
- 26 discrete size bins ranging from 0.1 to 26mm used to create a particle size distribution each minute

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





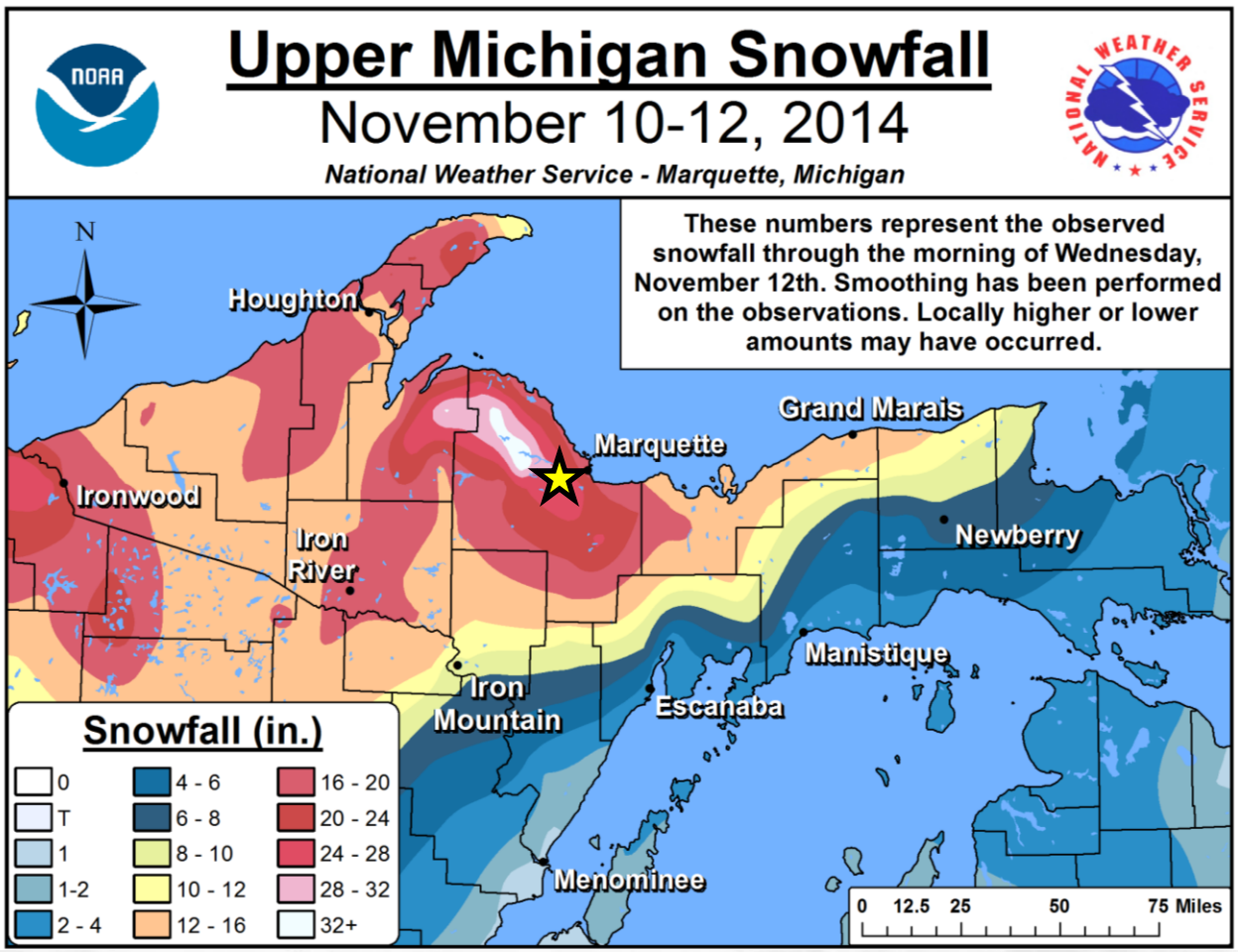
WFO Marquette Research Field



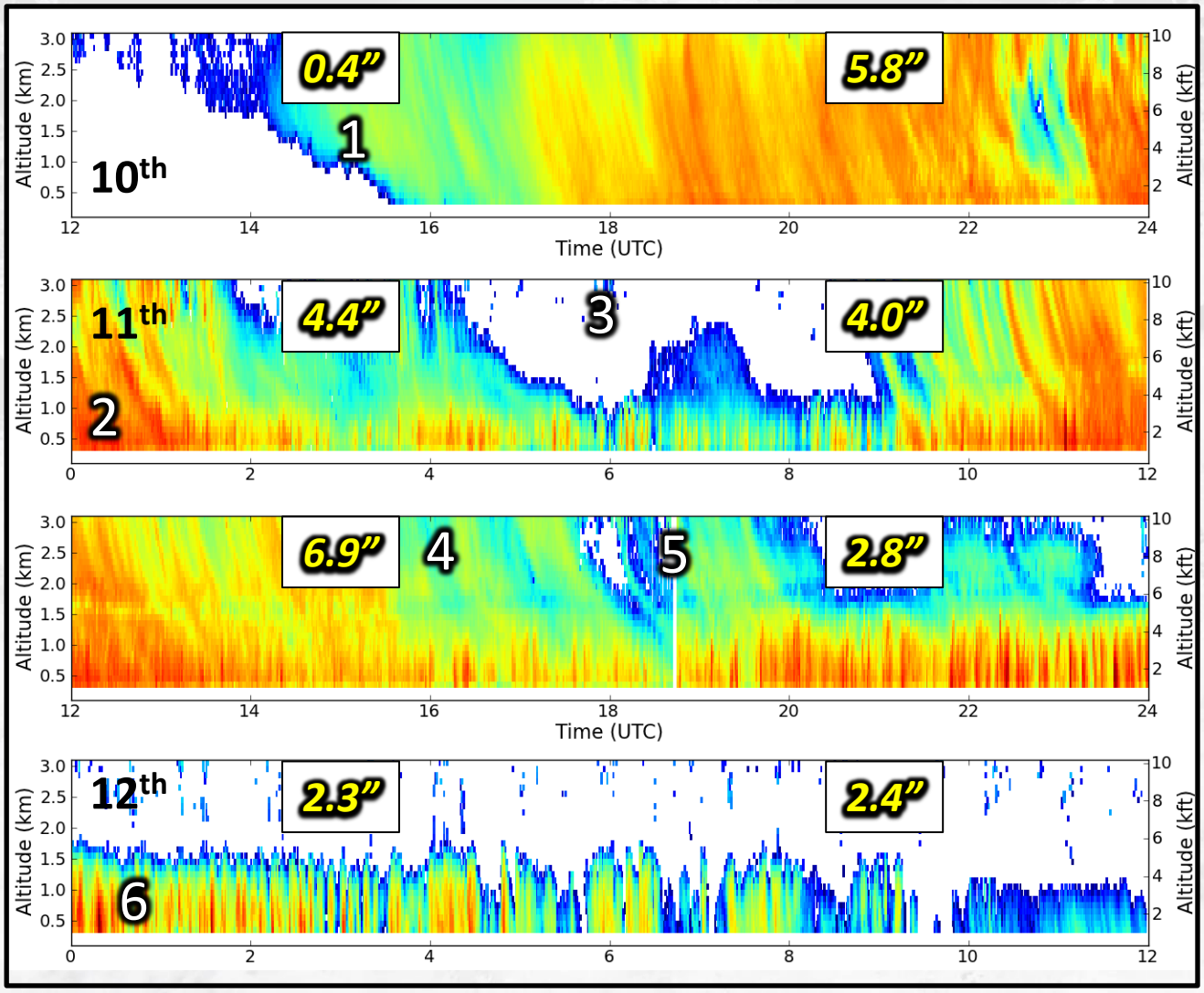
Case 1: Synoptic to LES Transition

- November 10th through 12th, 2014
- 30.2” three-day snowfall at NWS Marquette

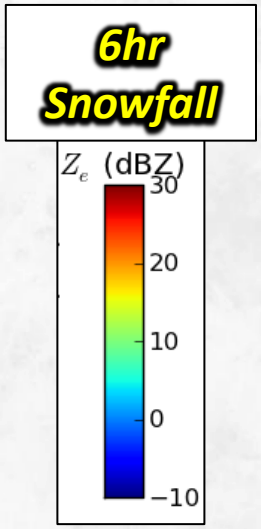
Date	Time (UTC)	6hr Snow (in)	6hr Precip (in)
10	18	0.4	0.05
11	00	5.8	0.68
	06	4.4	0.52
	12	4.0	0.50
	18	6.9	0.81
12	00	2.8	0.30
	06	2.3	0.26
	12	2.4	0.09
	18	1.2	0.03
Totals		**30.2**	**3.24**



Case 1: System to LES Transition

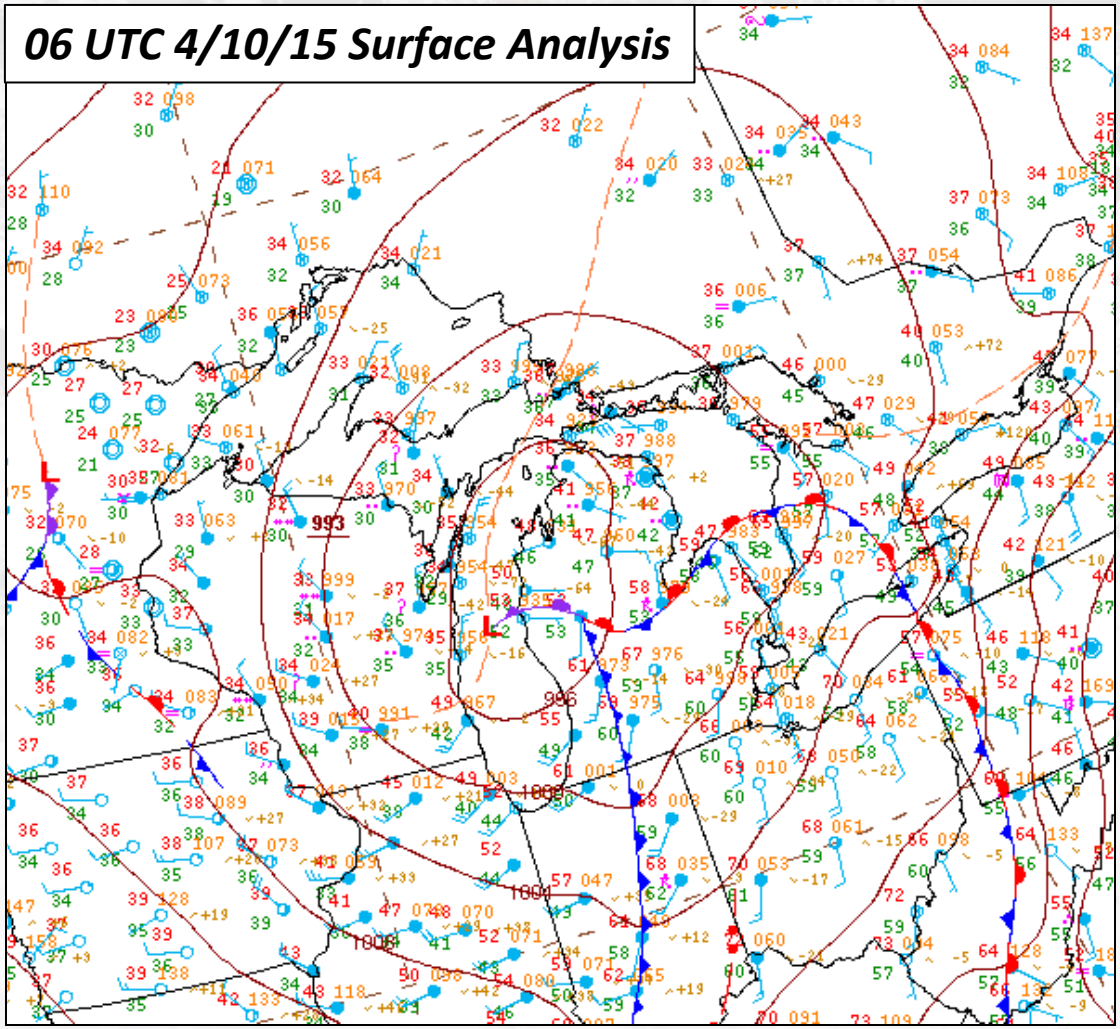


1) Precip. begins
2) +SN
3) LE/topo
   -SN & FZDZ
4) Dish heater fails
5) Dish cleared
6) LES



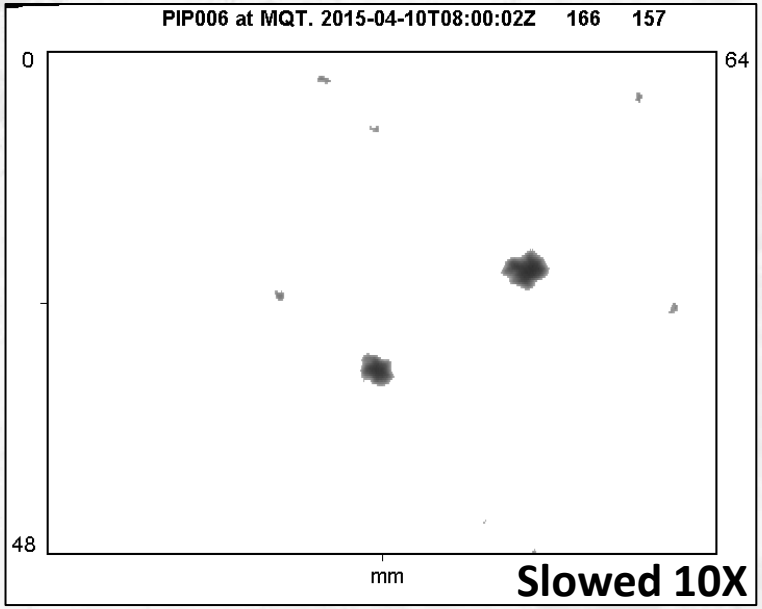
Case 2: Mixed-precipitation

April 10th, 2015



7.9” of snow with 0.92” of liquid equivalent at NWS Marquette 06-12 UTC. Rate of 2”/hr 07-10 UTC.

Wx at WFO MQT (UTC) 4/10	
-FZRA	0019 – 0620
-SN/PL	0620 – 0700
SN	0700 – 0715
+SN	0715 – 1200
SN	1200 – 1300



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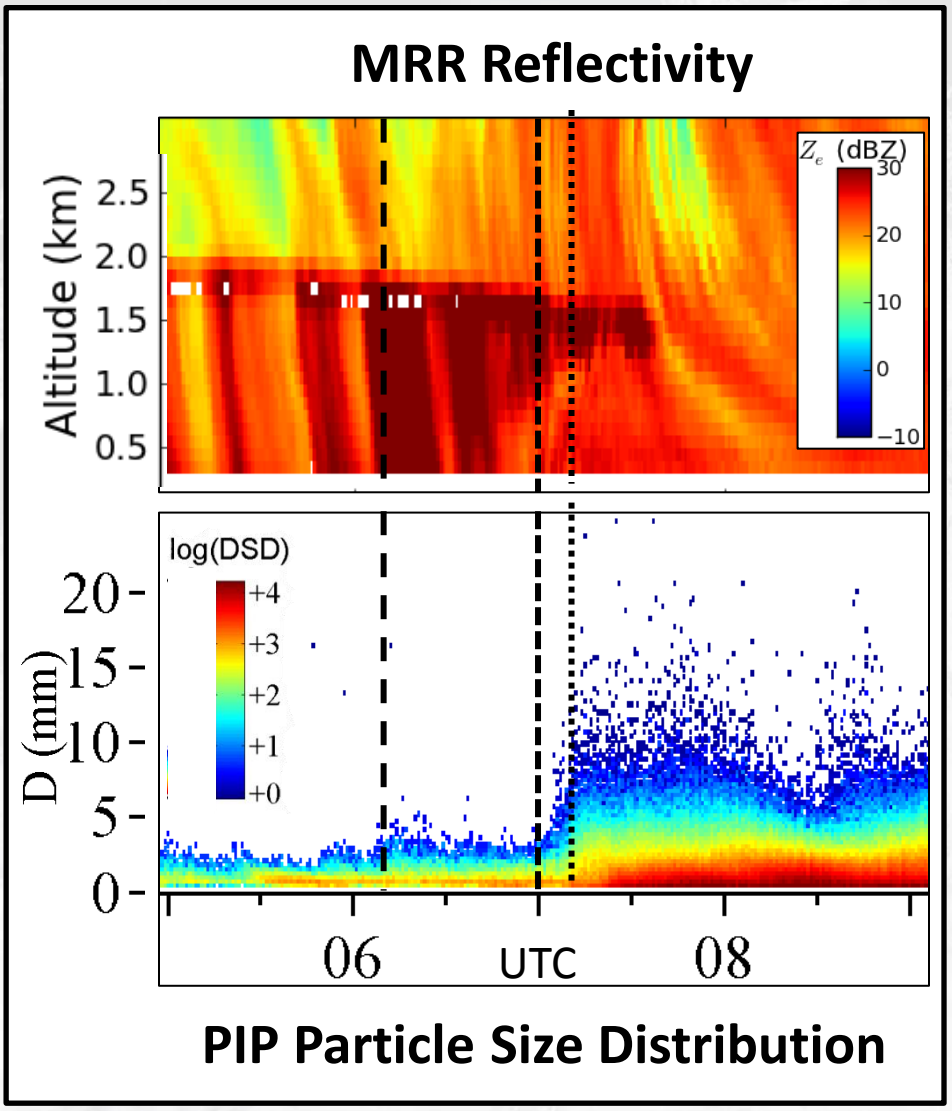
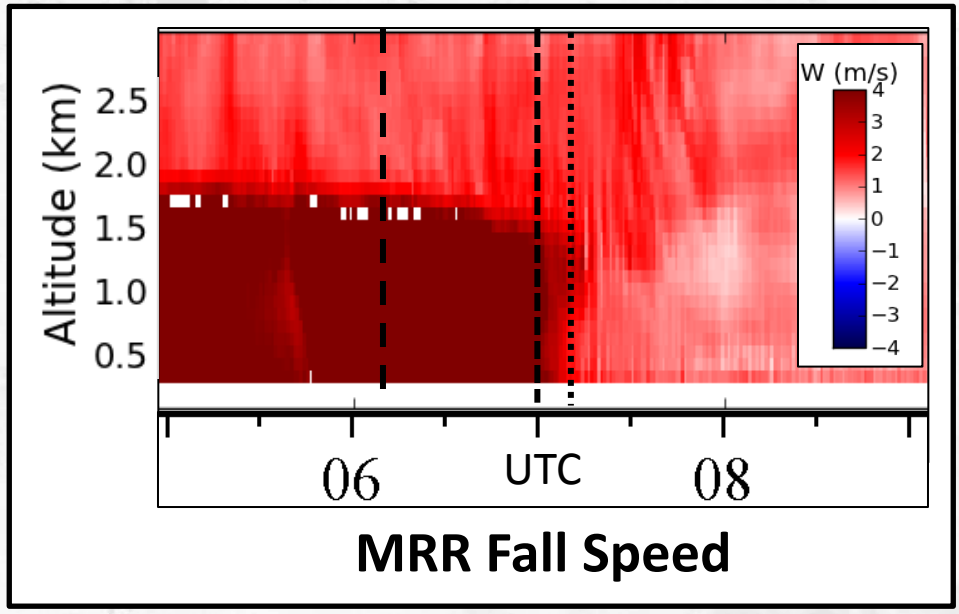


- - - - - - FZRA → - SN/PL

- - - - - - - SN/PL → SN

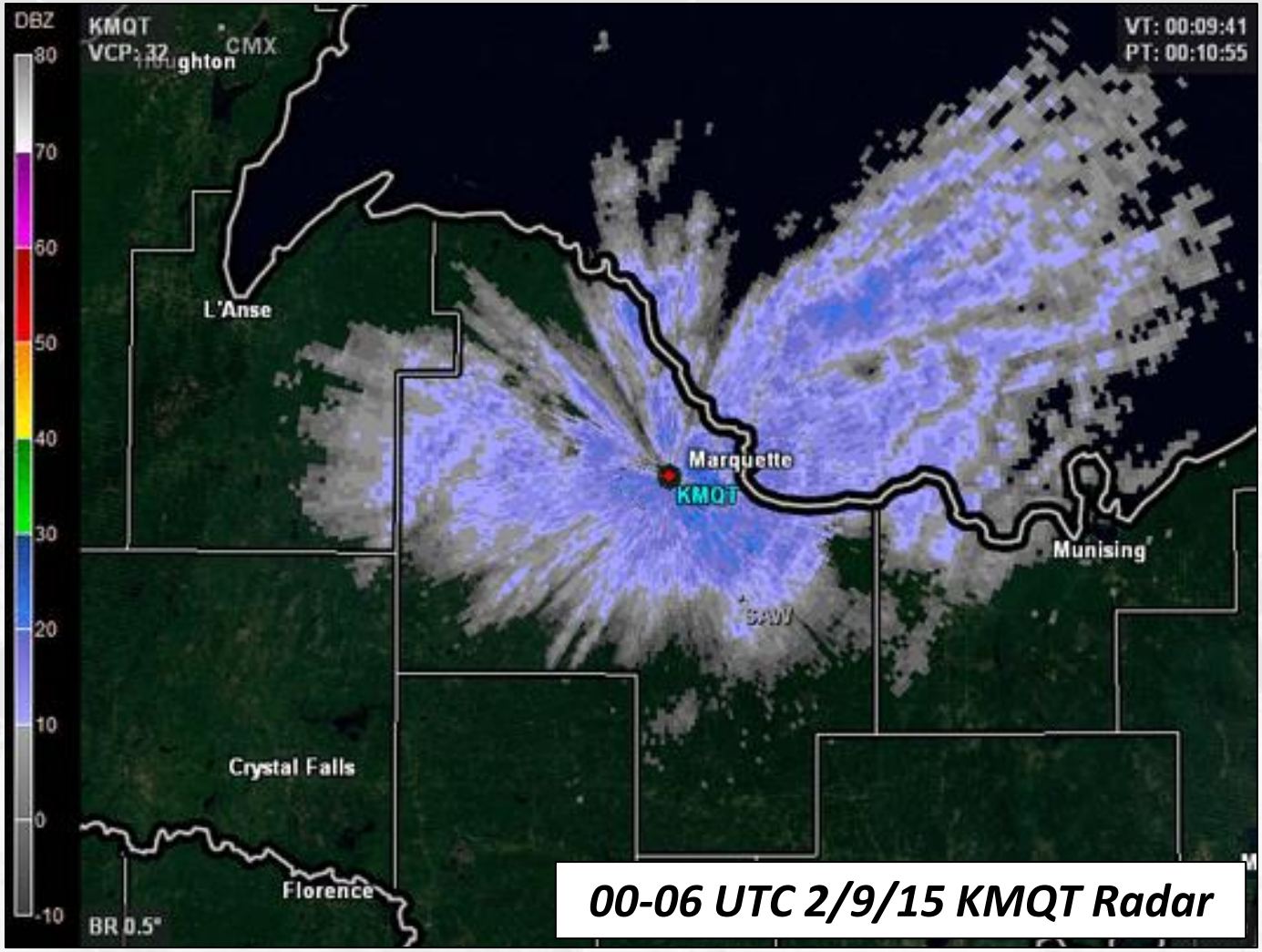
..... SN → +SN



Case 3: High Snow-to-Liquid Ratio

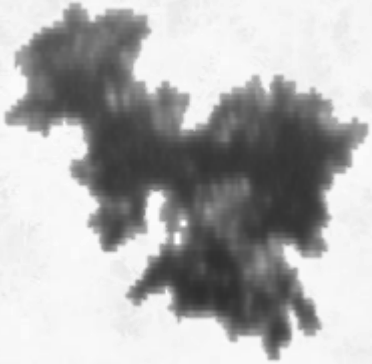
- February 8th and 9th, 2015
- 11.5” of snow with 0.17” liquid
  - Snow-to-liquid ratio (SLR) of ***68:1***
- Ice cover increasing on Lake Superior (25% coverage, lake SST ~33F)
- Some topographic influence: 827’ elevation gain over ~7mi from Lake Superior to NWS Marquette

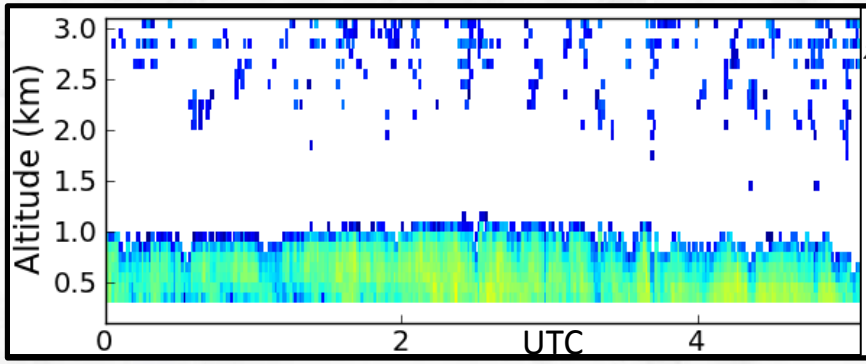
Date	Time (UTC)	6hr Snow (in)	6hr Precip (in)
8	12	0.7	0.03
	18	2.0	0.03
9	00	2.6	0.04
	06	4.3	0.05
	12	0.4	T
	18	1.5	0.02
Totals		**11.5**	**0.17**

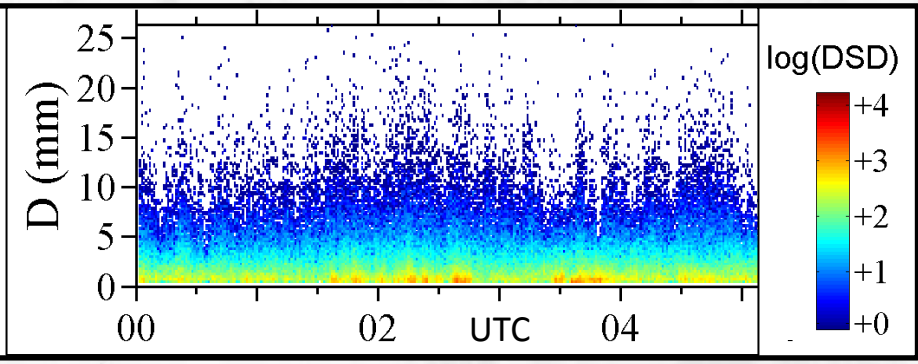


00-06 UTC 2/9/15 KMQT Radar

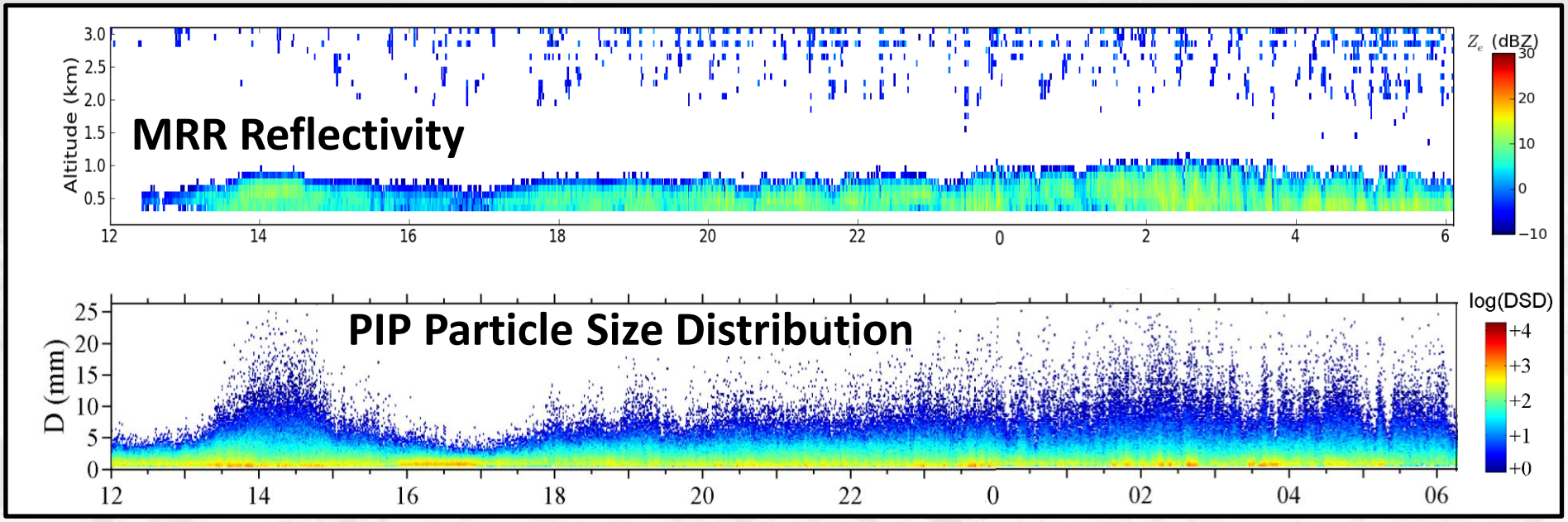
PIP images of aggregates from 2/9/15

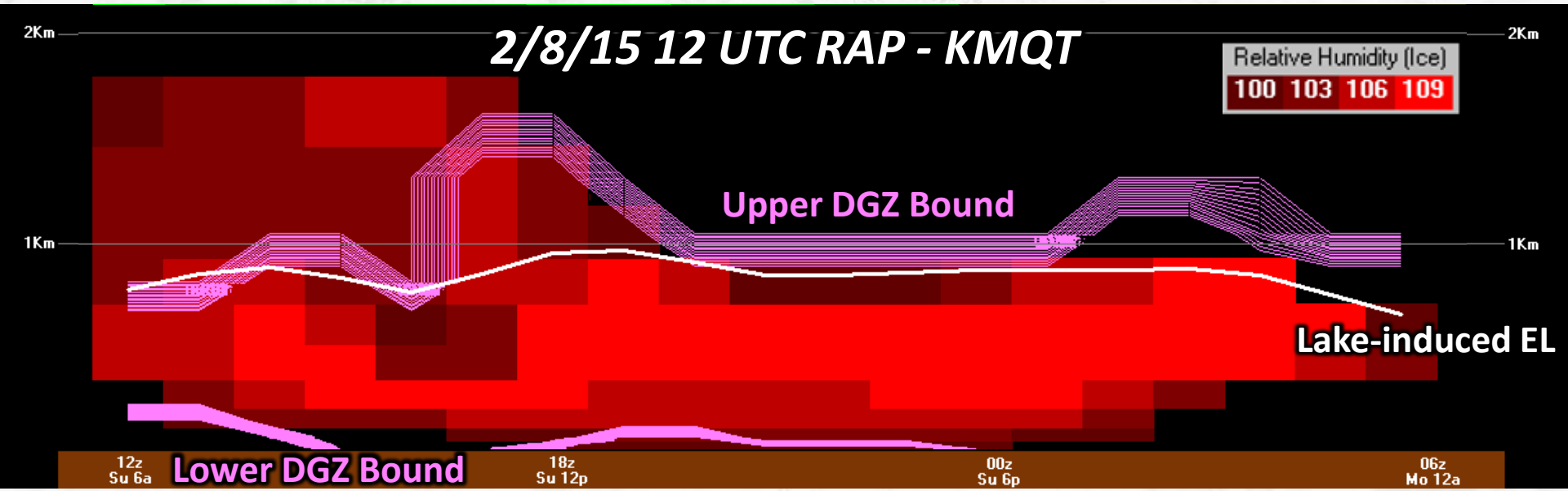






2/8/15 12 UTC – 2/9/15 06 UTC





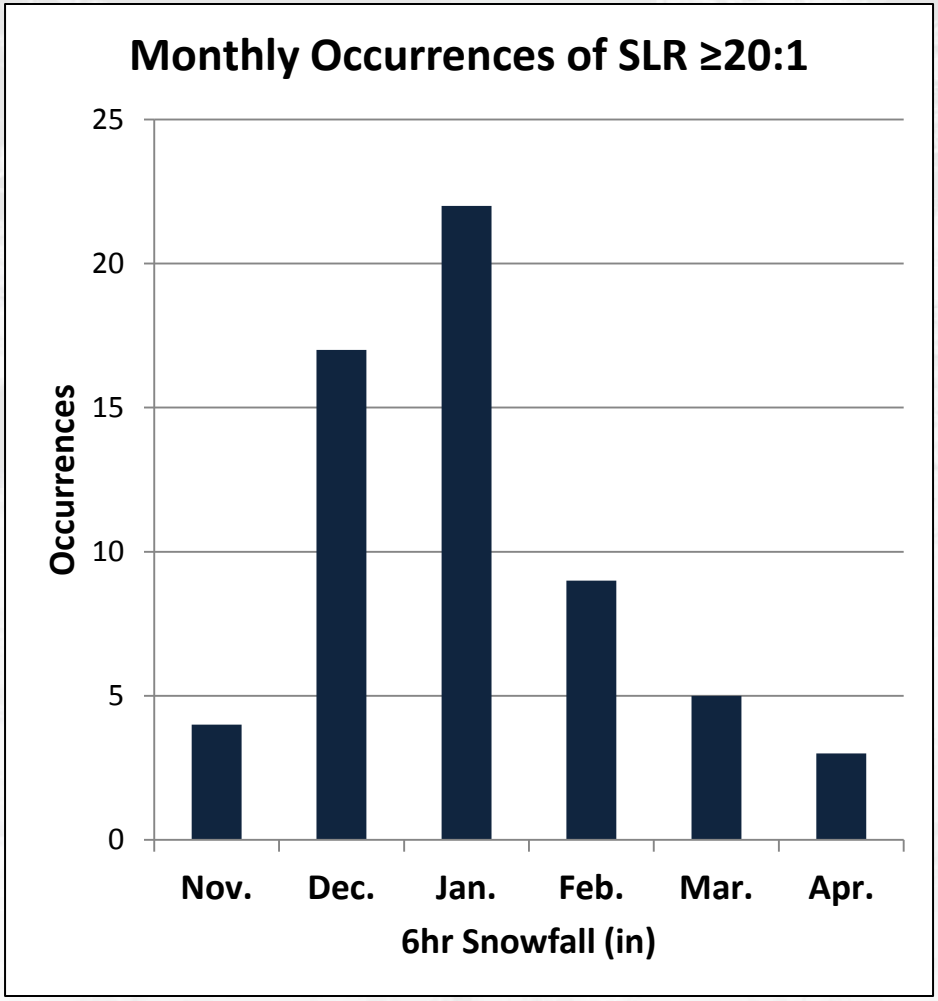
Local SLR Research

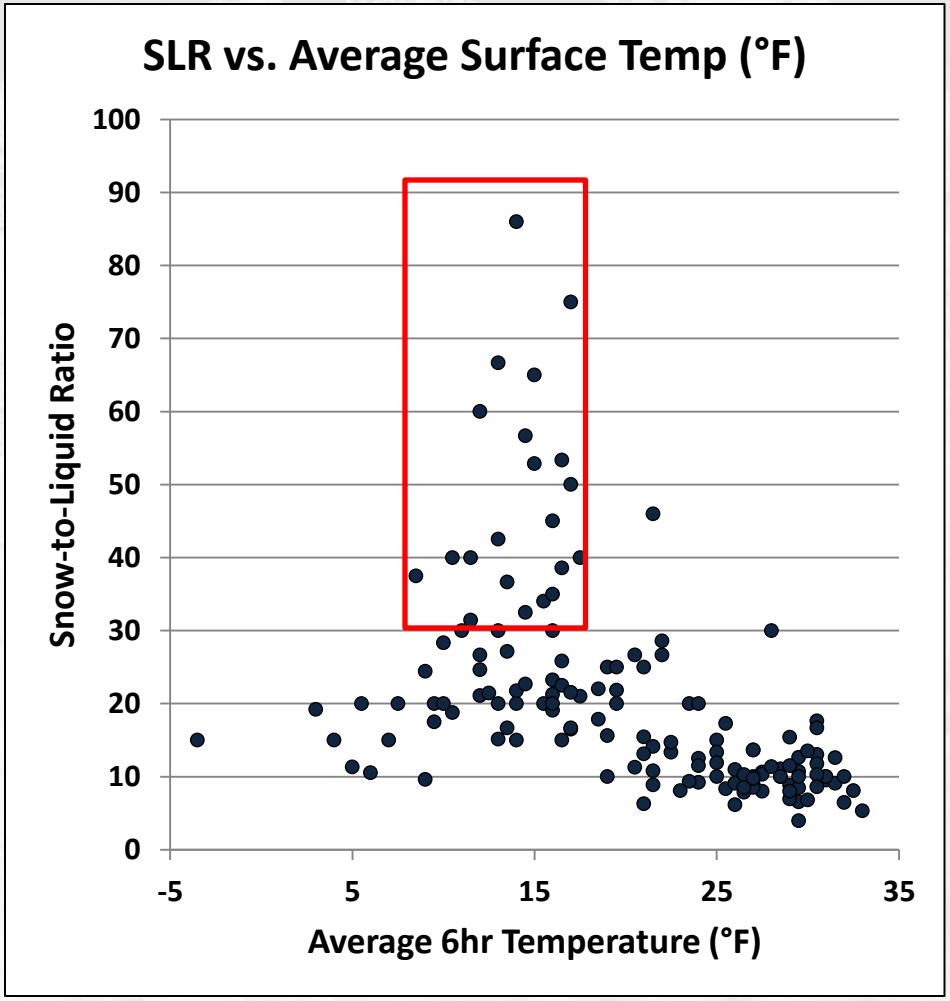
- **Goal:** determine local characteristics of high SLRs using 6hr obs and MRR/PIP data
- Errors in snowfall forecasts are compounded with higher SLRs

Forecast Errors for 0.25” QPF			
SLR	**10**	**20**	**30**
Snow	**2.5”**	**5”**	**7.5”**
Snow w/ ±20% SLR Error	**2-3”**	**4-6”**	**6-9”**

- Analyze NWS Marquette 6hr snowfall measurements
  - 2010-11 through 2014-15 seasons
  - Compiled SLR values for each 6hr snowfall ≥ 1.5”
  - Calculated average temp of 6hr max and min temps
  - Removed cases where 6hr max and min temp differed by ≥7°F
  - 147 six-hour periods identified

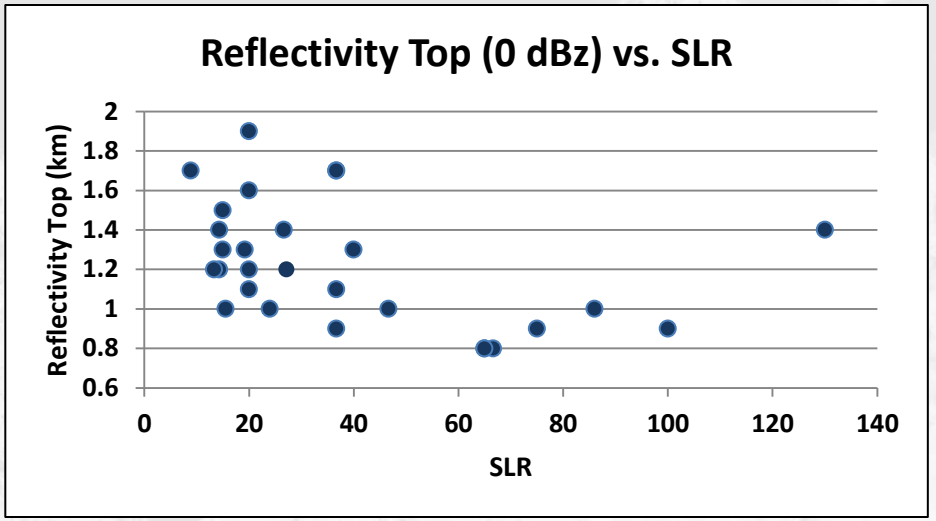
6hr Snowfall ≥ 1.5”



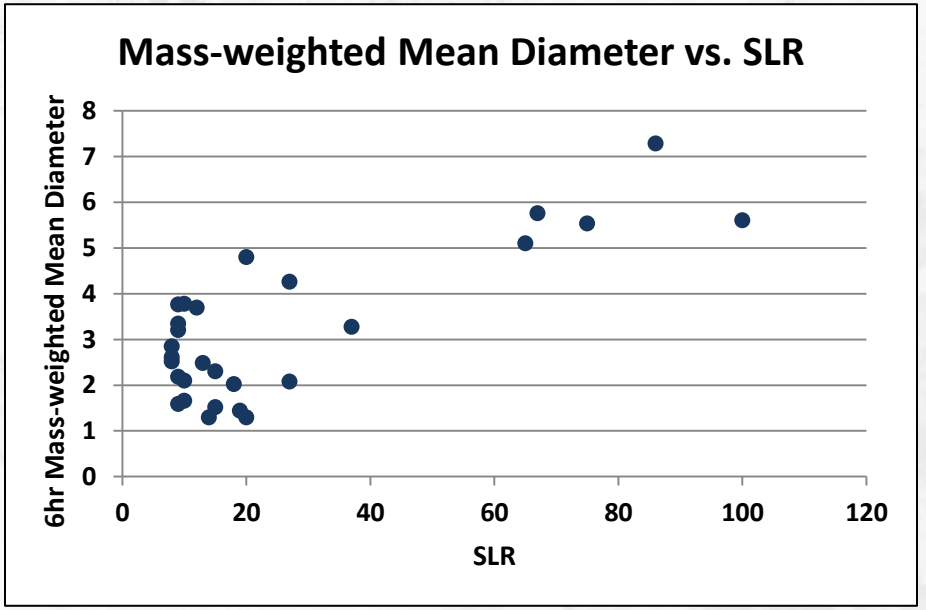


Expansion Using MRR-PIP Data

- Potential for in-depth analysis of snowflake and environment characteristics



- Limitations
  - Only one full winter of data at one location
    - Too few samples
    - Not statistically independent
  - Snow ratios change
  - Stronger winds affect SLRs

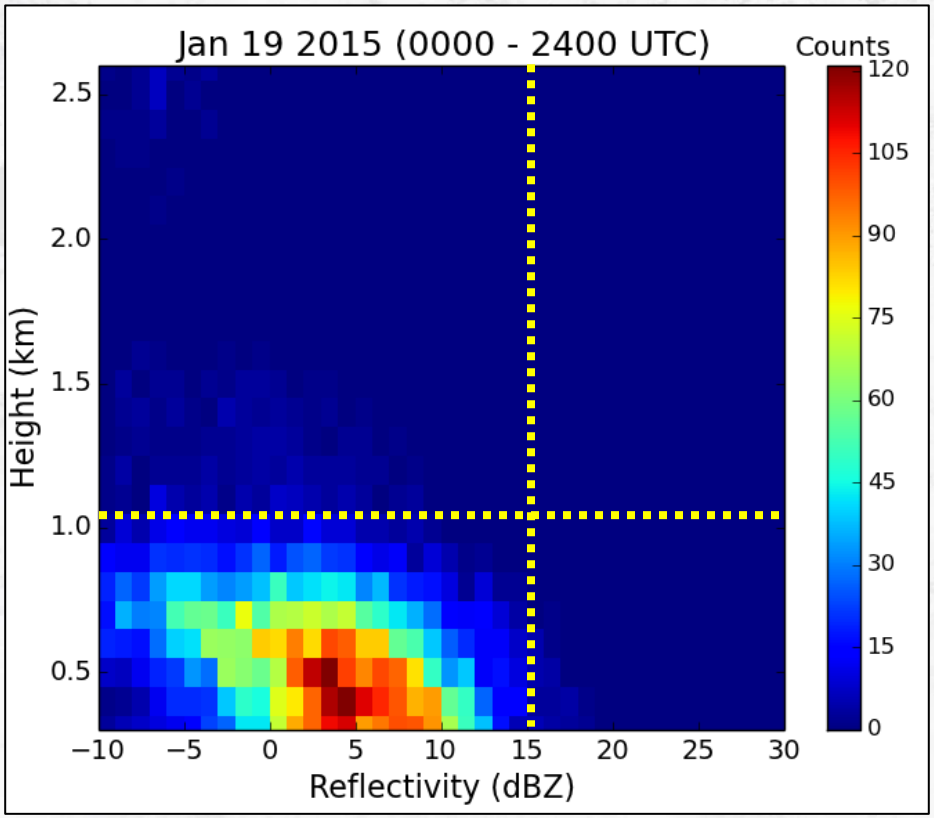


Expansion Using MRR-PIP Data

MRR Contoured Frequency by Altitude Diagrams (CFADs)

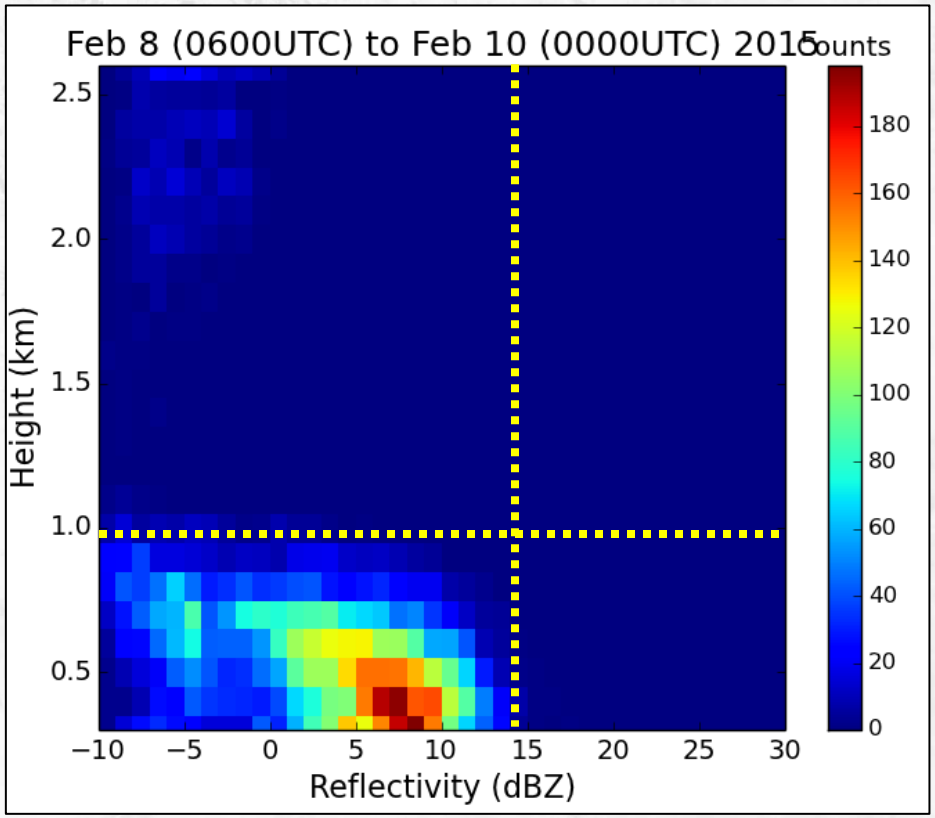
January 19, 2015

SLR of 53:1 (3.7” snow w/ 0.07” liquid)



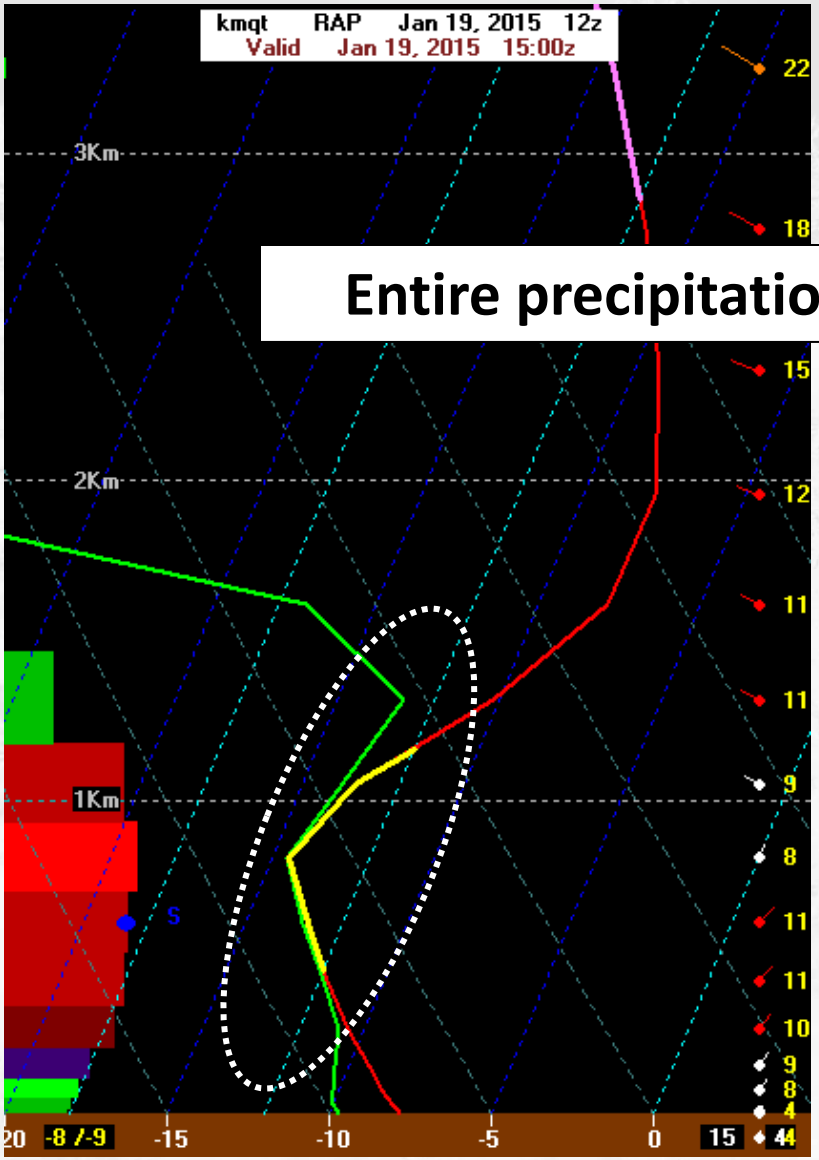
February 8-9, 2015

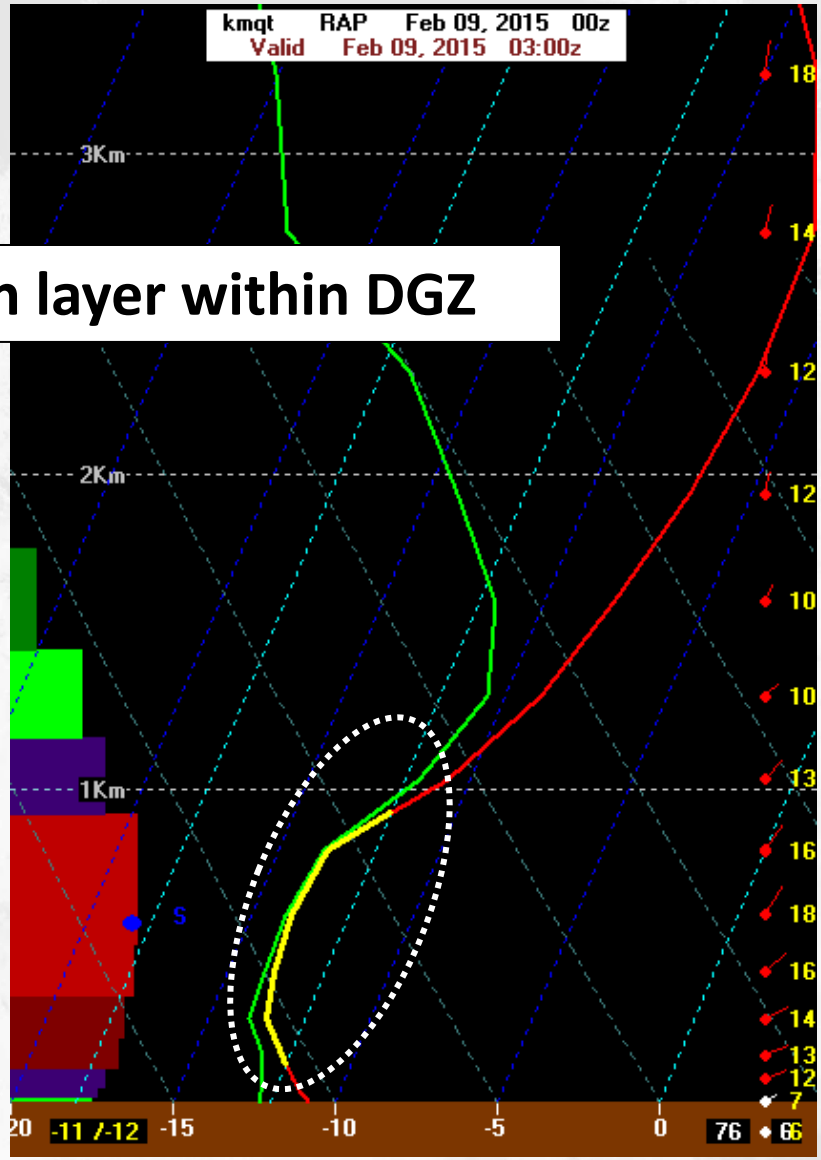
SLR of 68:1 (11.5” snow w/ 0.17” liquid)



Pettersen and Kulie, In Preparation

Soundings





Entire precipitation layer within DGZ

Summary

- MRR/PIP data can provide real-time data for operations
- MRR/PIP data will be useful to assist with the understanding of lake effect snow SLRs
- Preliminary results show that high SLR events at NWS Marquette tend to occur with shallow inversions and a temperature profile w/in the DGZ
- The upcoming winter season should provide more data to increase sample size and statistical independence