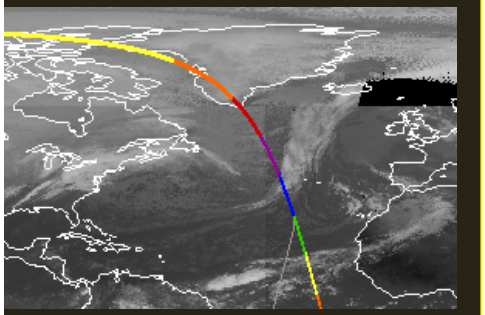
Postfrontal Convective Snow: A Combined Radar, Microwave Radiometer and Ice Microphysics Perspective

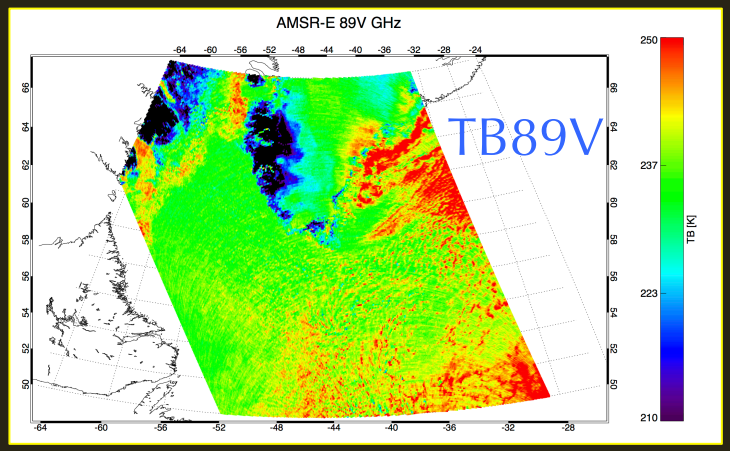
Mark Kulie, Claire Pettersen, Samantha Tushaus, Marian Mateling, Michael Dutter, Larry Bliven, Walt Petersen, David Wolff, Aronne Merrelli, Nai-Yu Wang, Yalei You, Lisa Milani, Norm Wood, Tristan L'Ecuyer, Dave Randel, Daniele Casella, Giulia Panegrossi

SSEC

WISCONSIN
UNIVERSITY OF WISCONSIN–MADISON

A-Train: 24 December 2008





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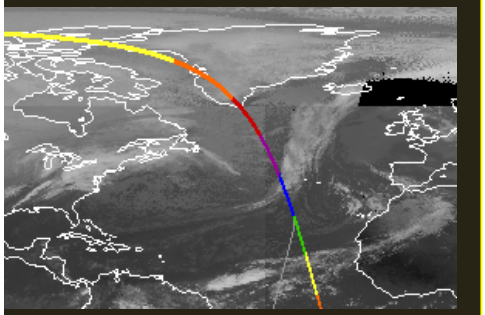

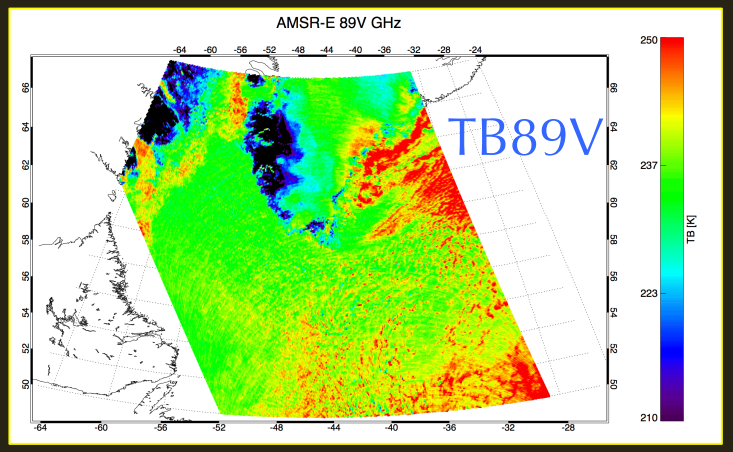

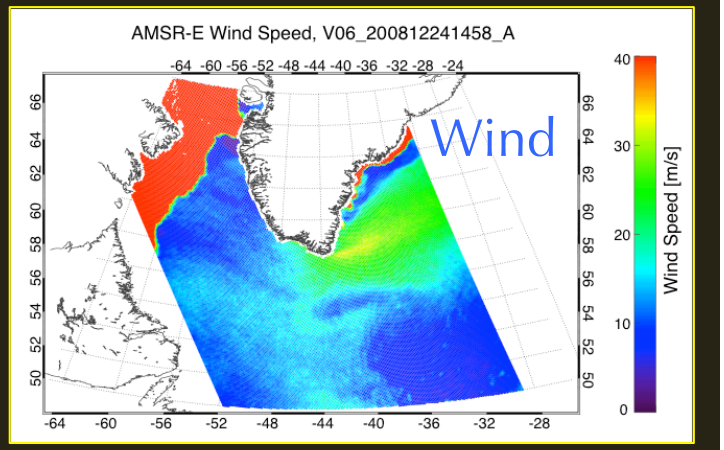

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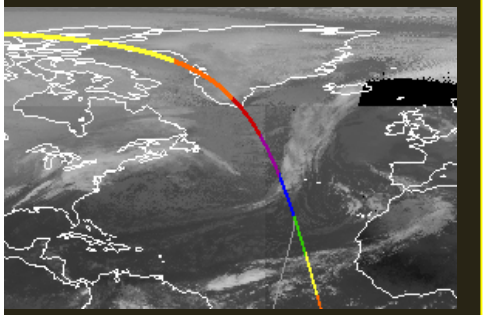

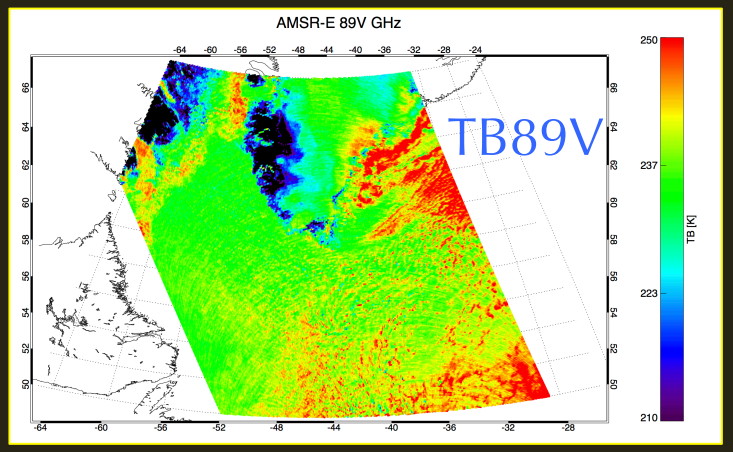

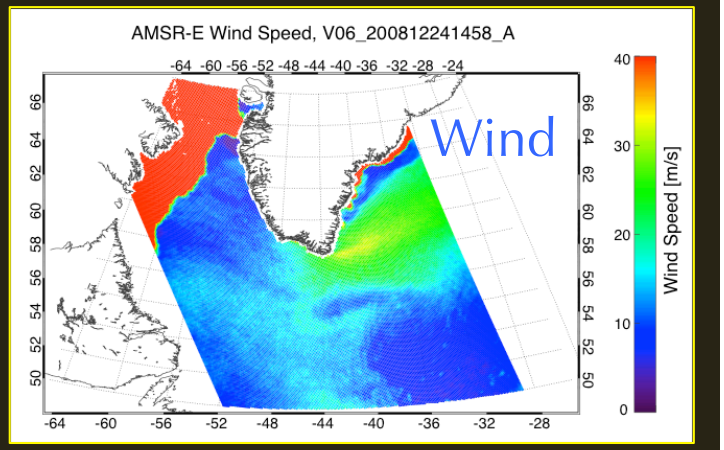

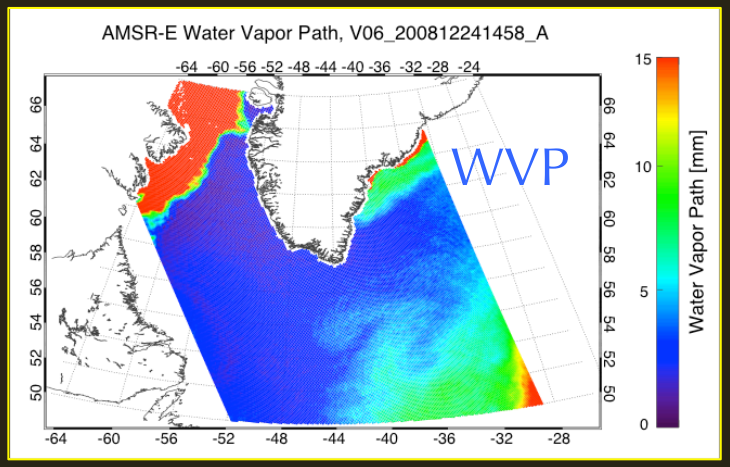

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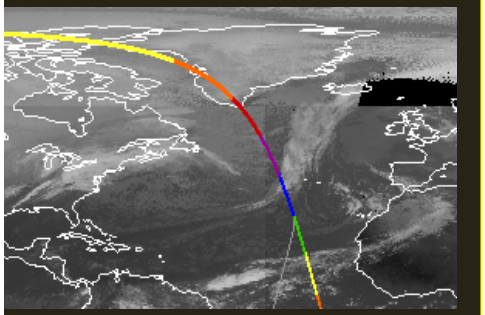

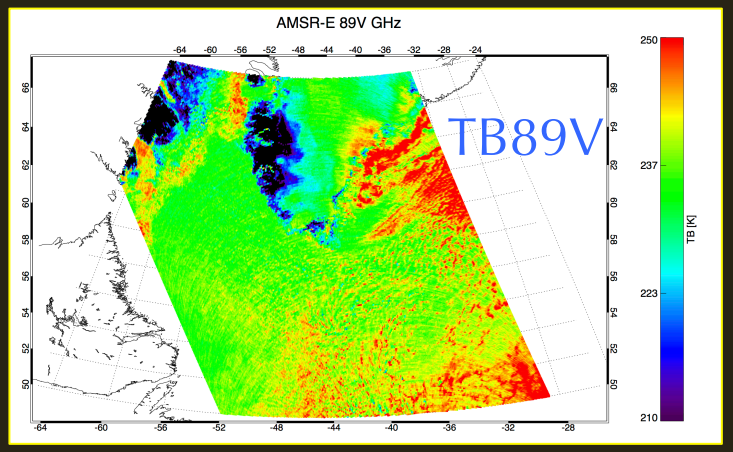

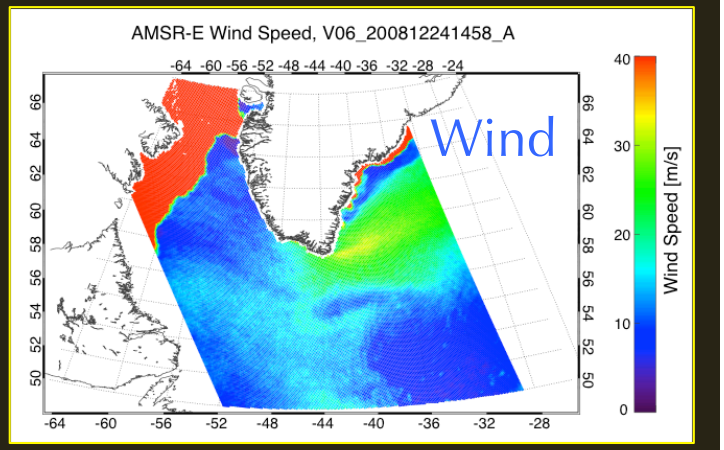

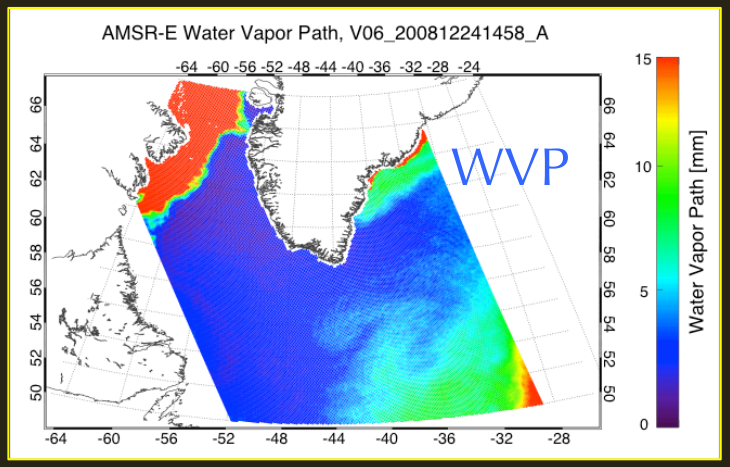

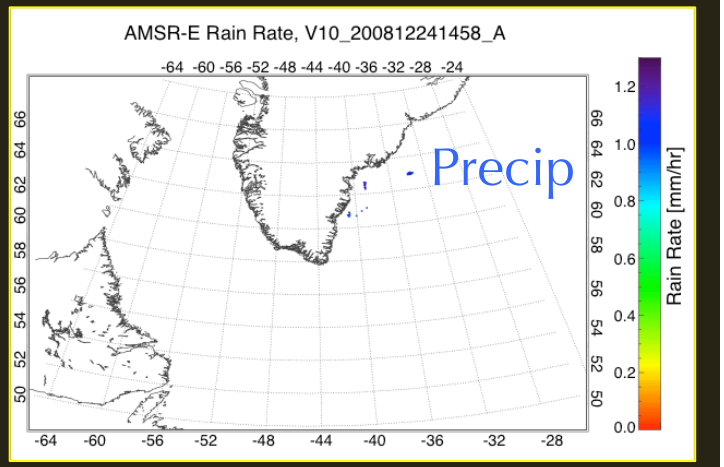

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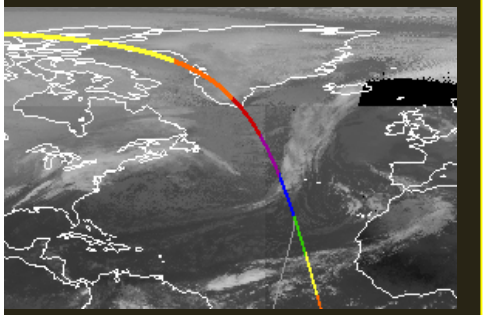
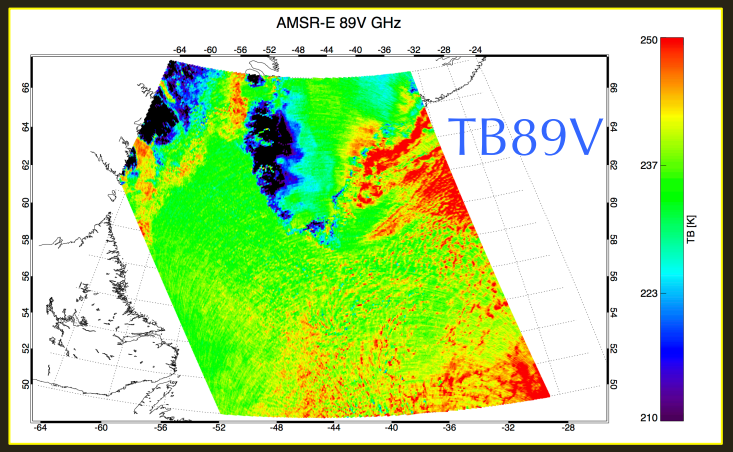
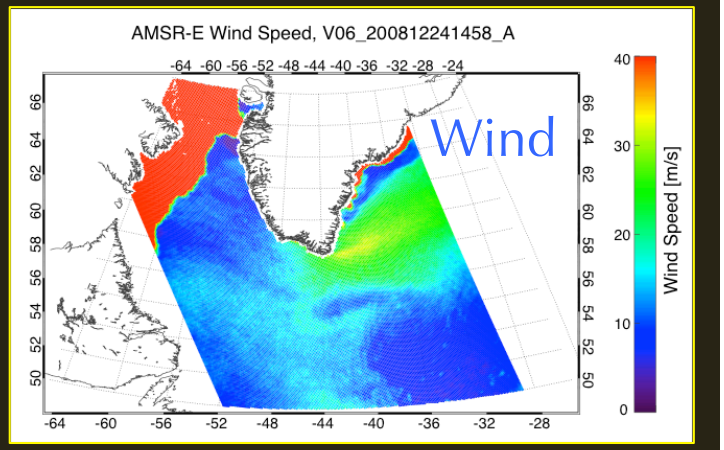
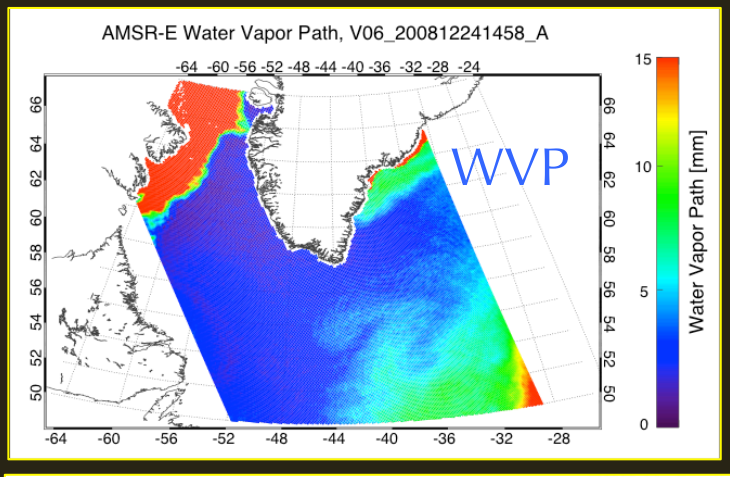
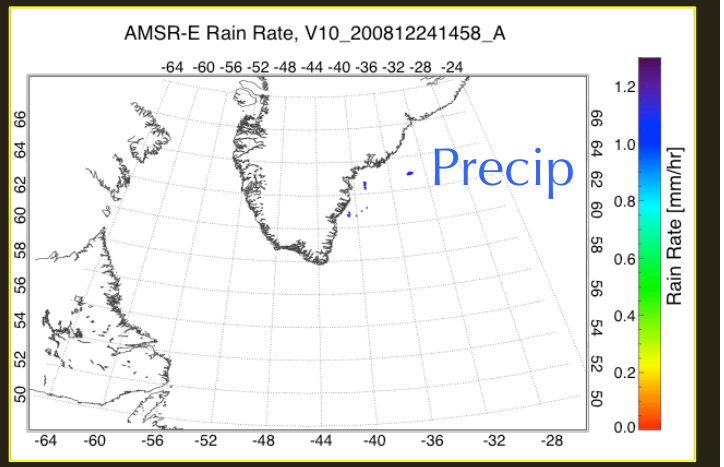
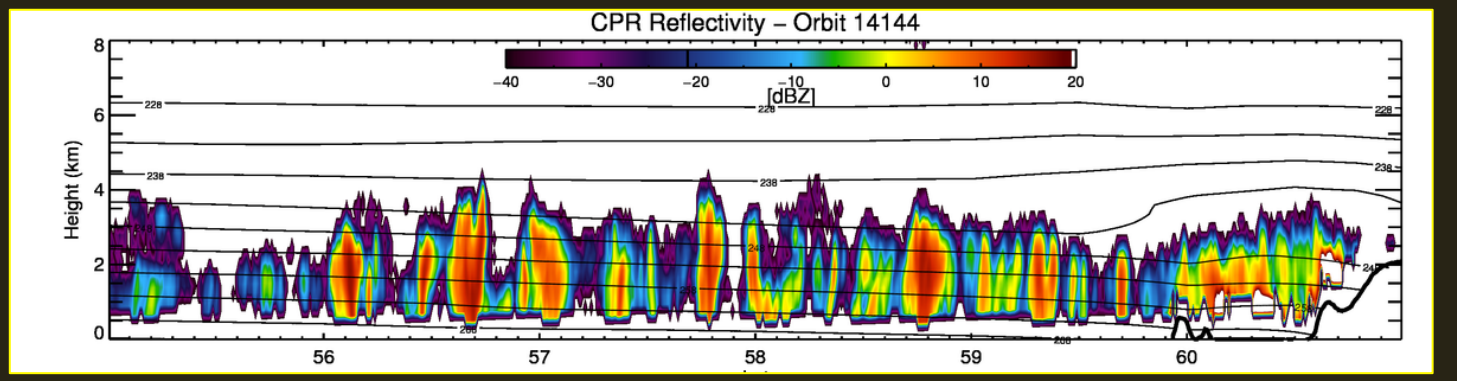




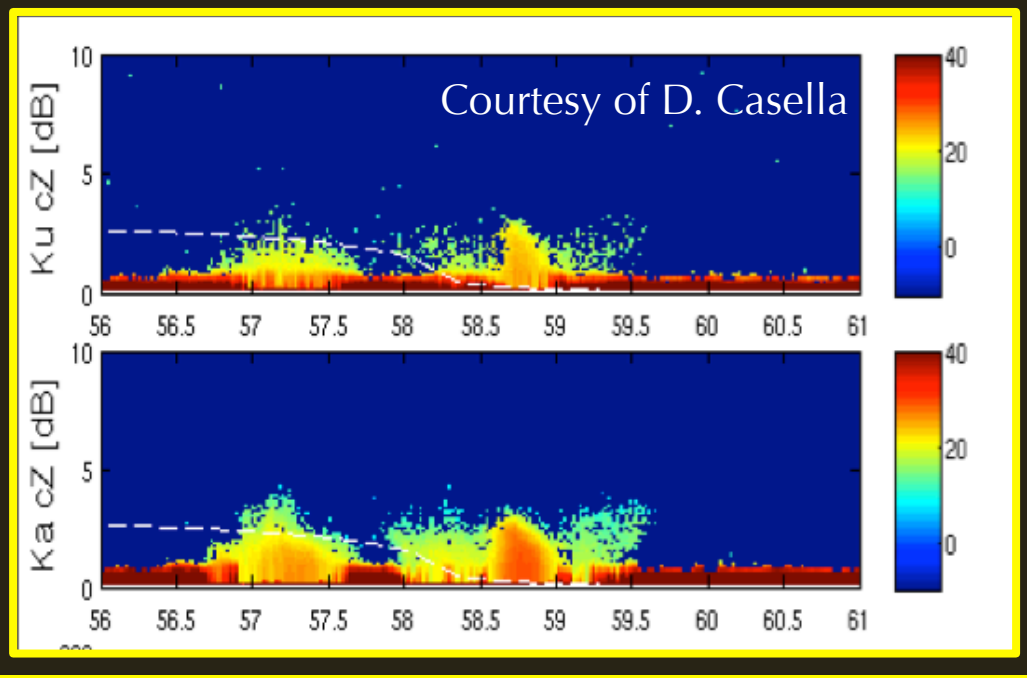


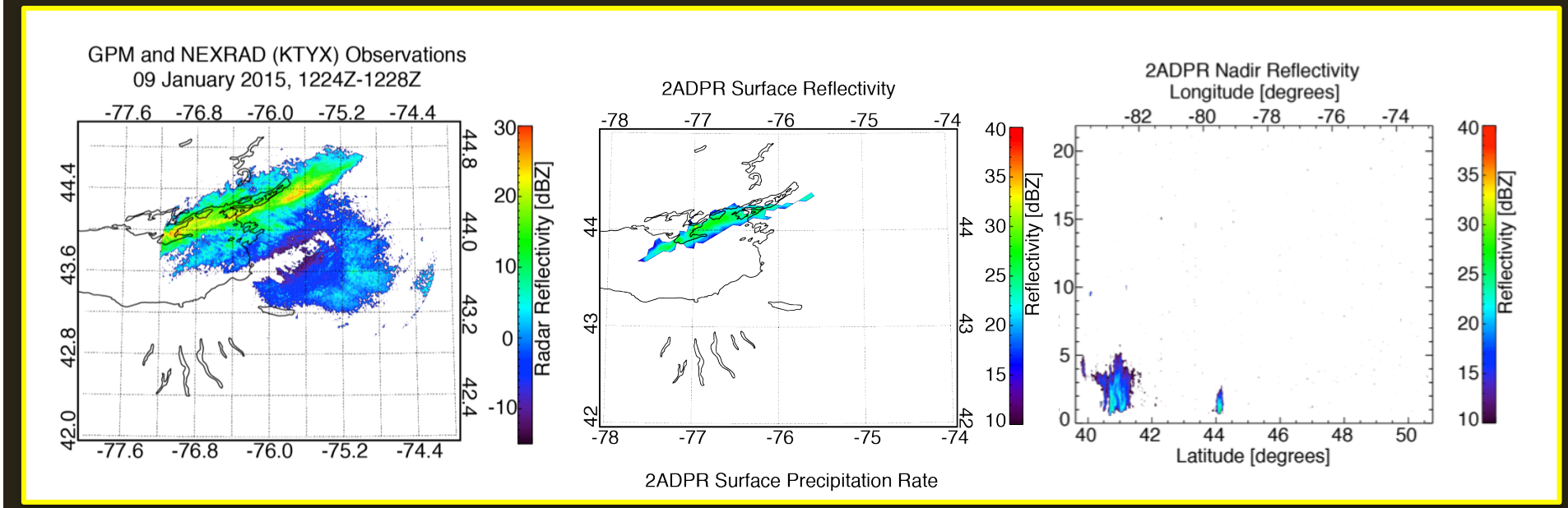




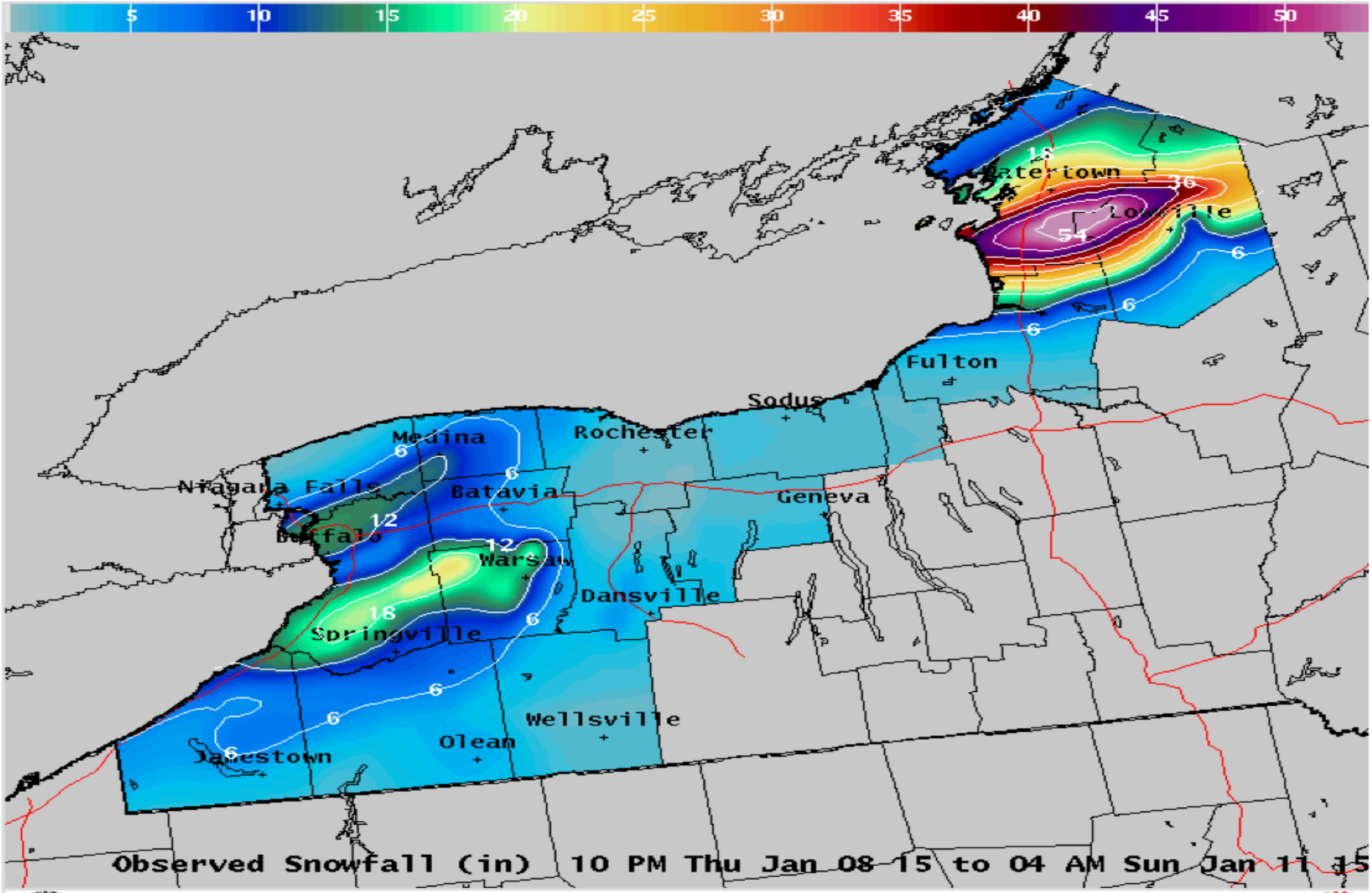


Convective Snow – GPM DPR



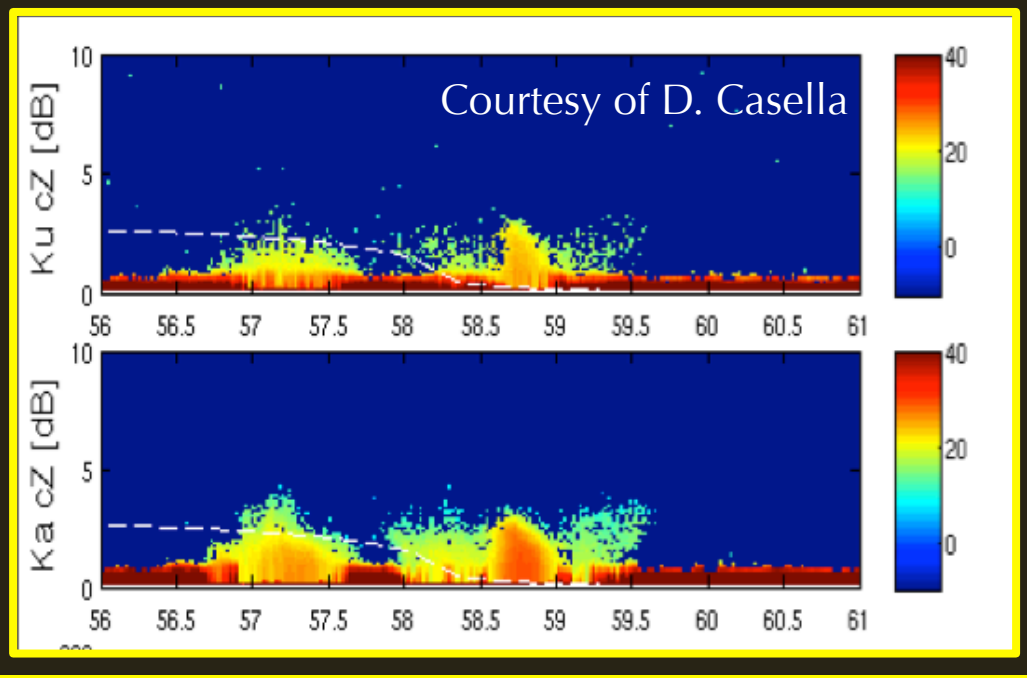


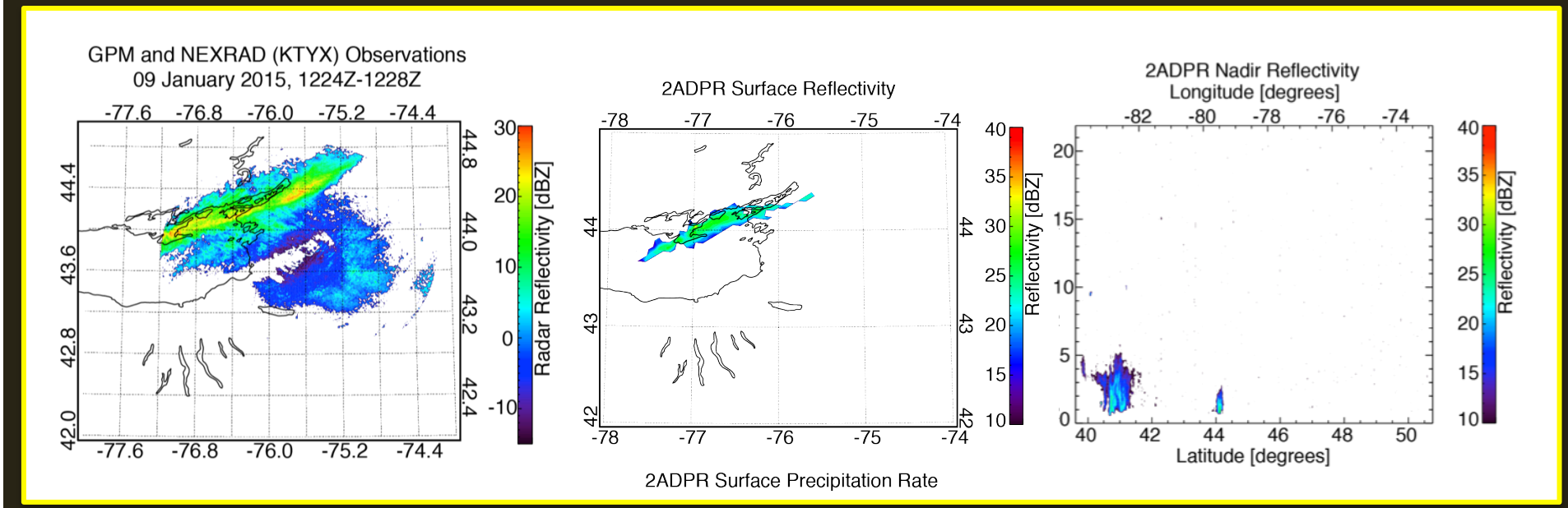
Lake Effect Summary - January 8 - 10, 2015



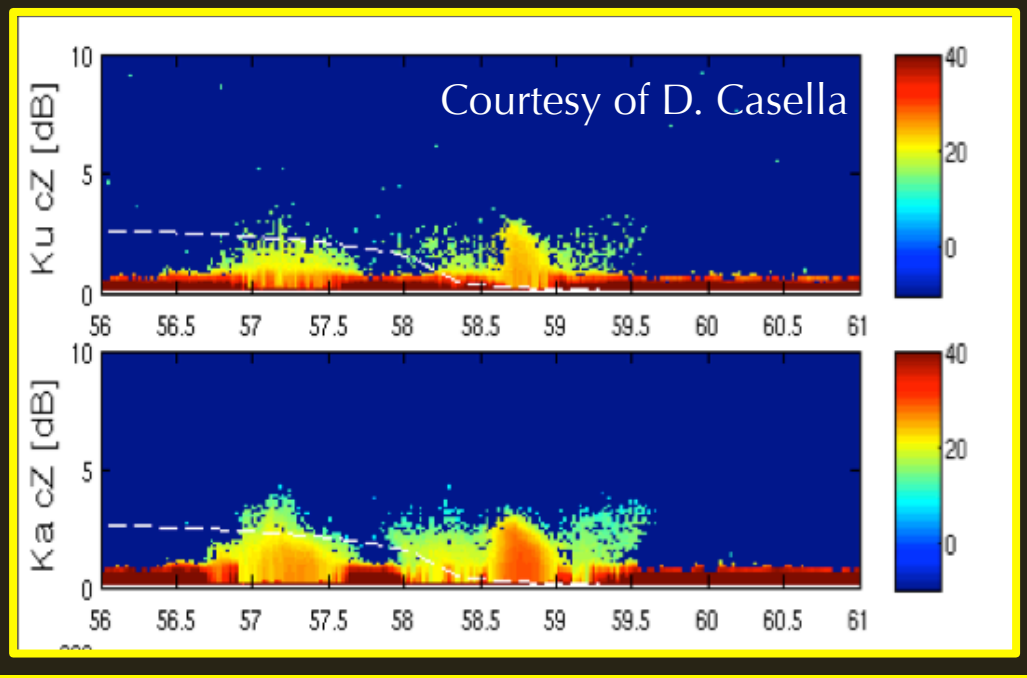
NWS Buffalo, NY

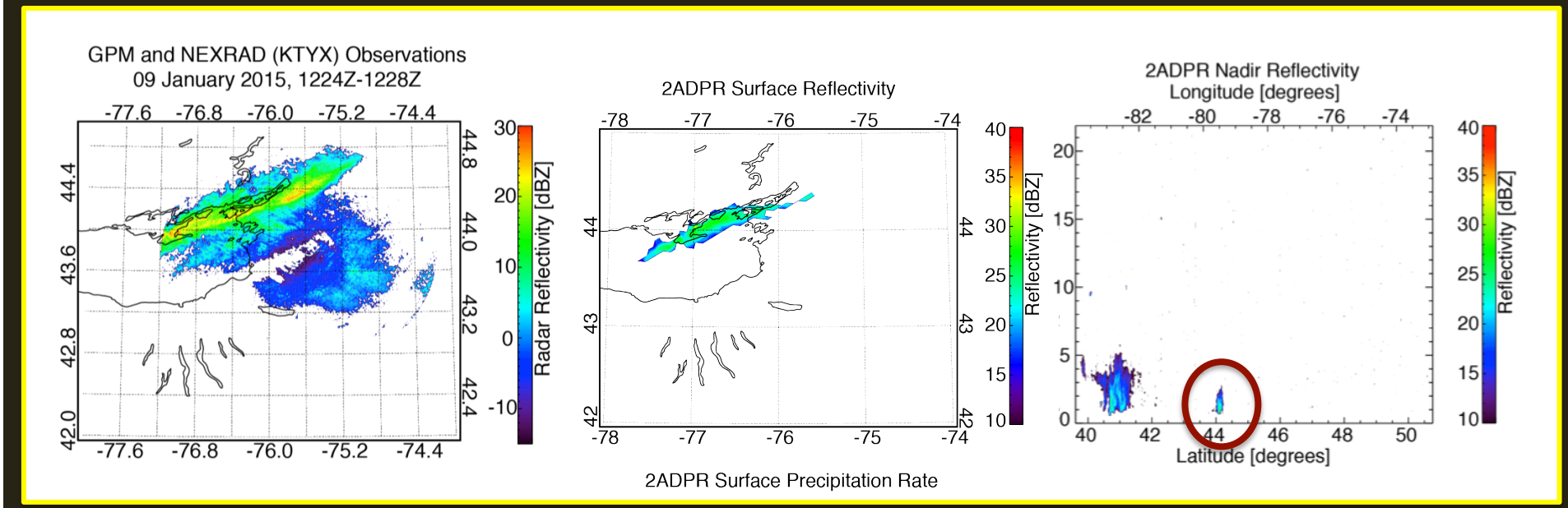
Convective Snow – GPM DPR





Convective Snow – GPM DPR





TRMM Shallow Rain

TRMM Radar Observations of Shallow Precipitation over the Tropical Oceans

DAVID A. SHORT AND KENJI NAKAMURA

Institute for Hydrospheric–Atmospheric Sciences, Nagoya University, Nagoya, Japan

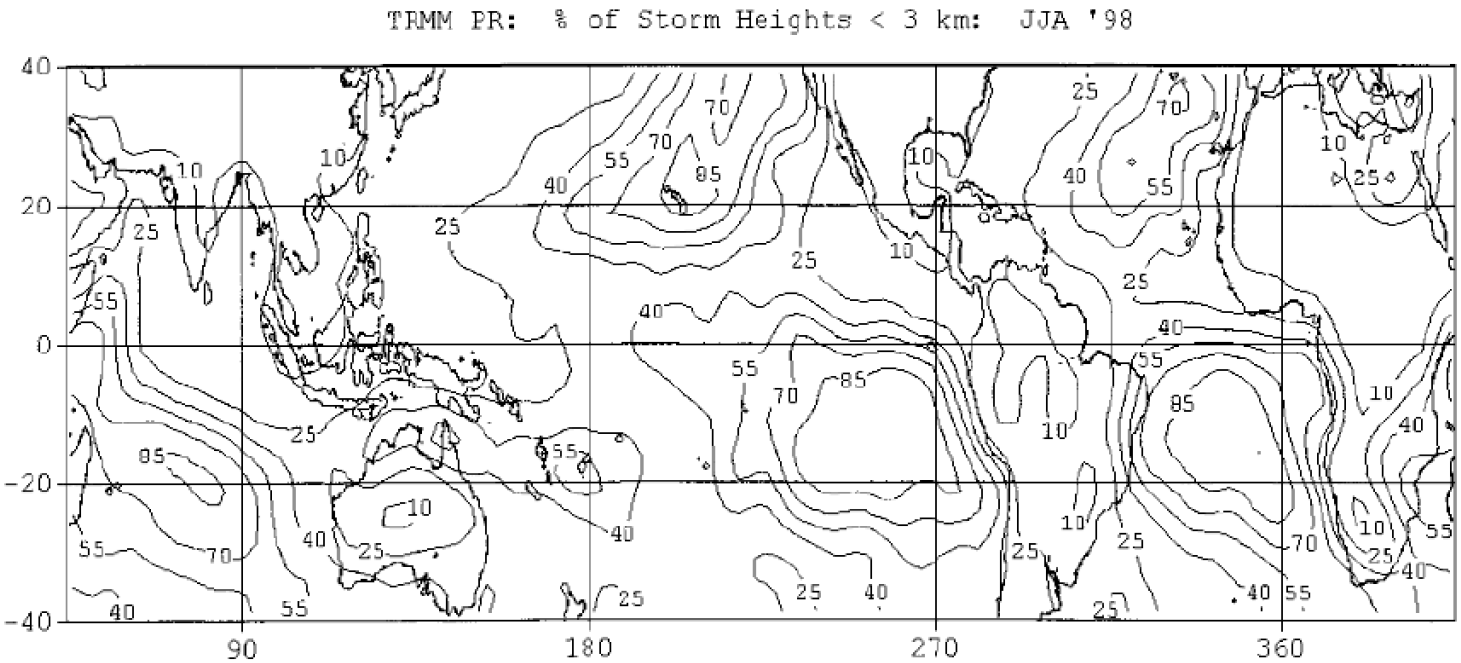


FIG. 3. Percentage of storm heights less than 3 km for JJA98.

TRMM Shallow Rain

The TRMM Precipitation Radar's View of Shallow, Isolated Rain

COURTNEY SCHUMACHER AND ROBERT A. HOUZE JR.

Department of Atmospheric Sciences, University of Washington, Seattle, Washington

14 August 2002 and 17 March 2003

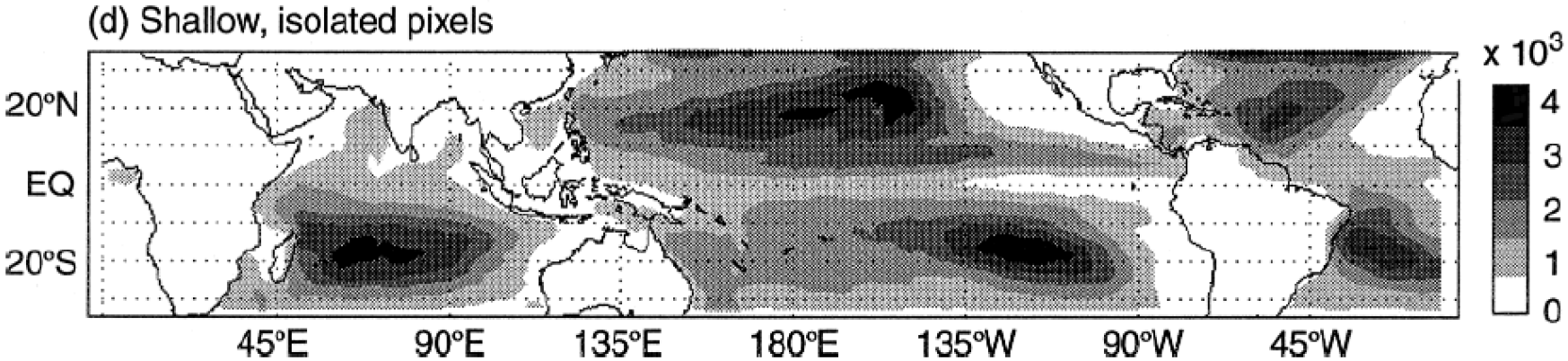


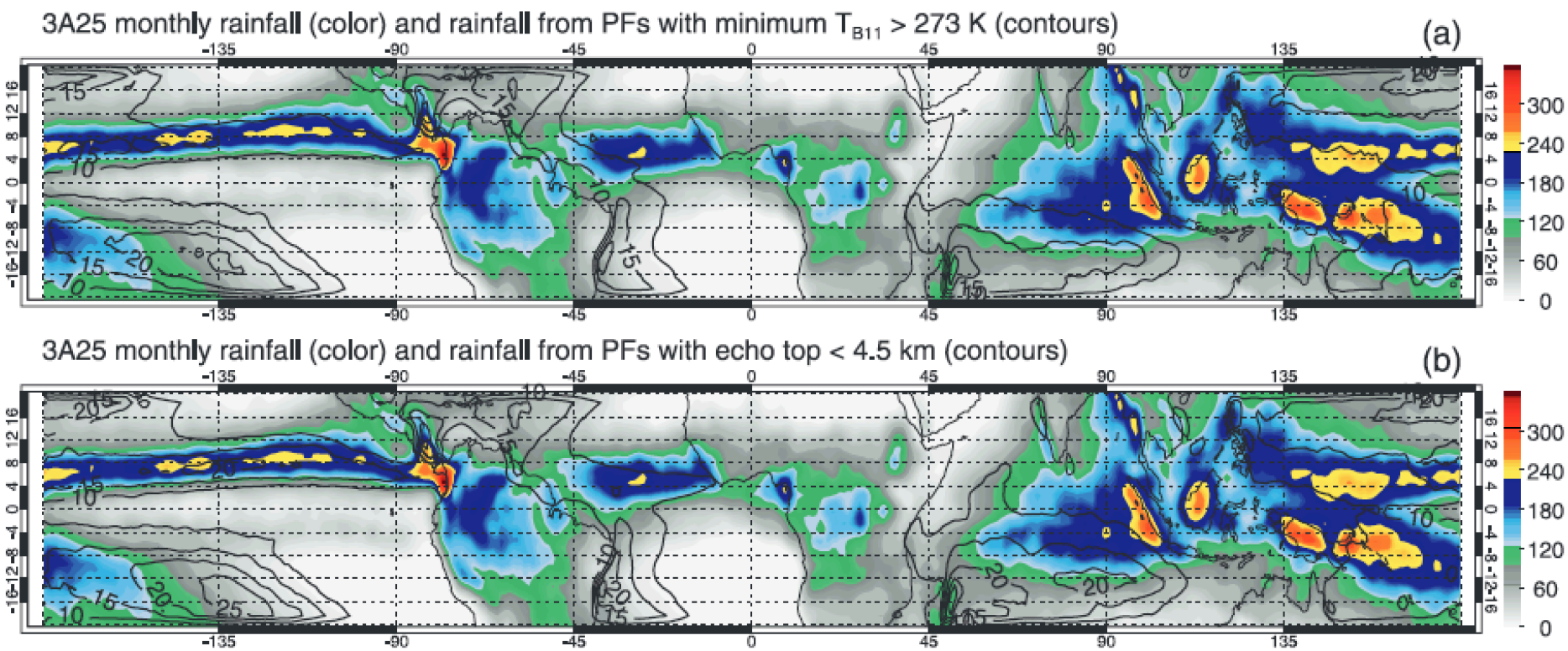
FIG. 1 TRMM version-5 PR 2.58 observations from 1998 to 2000 for annually averaged (a) rain, (b) stratiform pixel count (rain-types 10–14), (c) convective pixel count (rain-types 20–25), and (d) shallow, isolated pixel count (rain-types 15, 26–29).

TRMM Shallow Rain

"Warm Rain" in the Tropics: Seasonal and Regional Distributions Based on 9 yr of TRMM Data

CHUNTAO LIU AND EDWARD J. ZIPSER

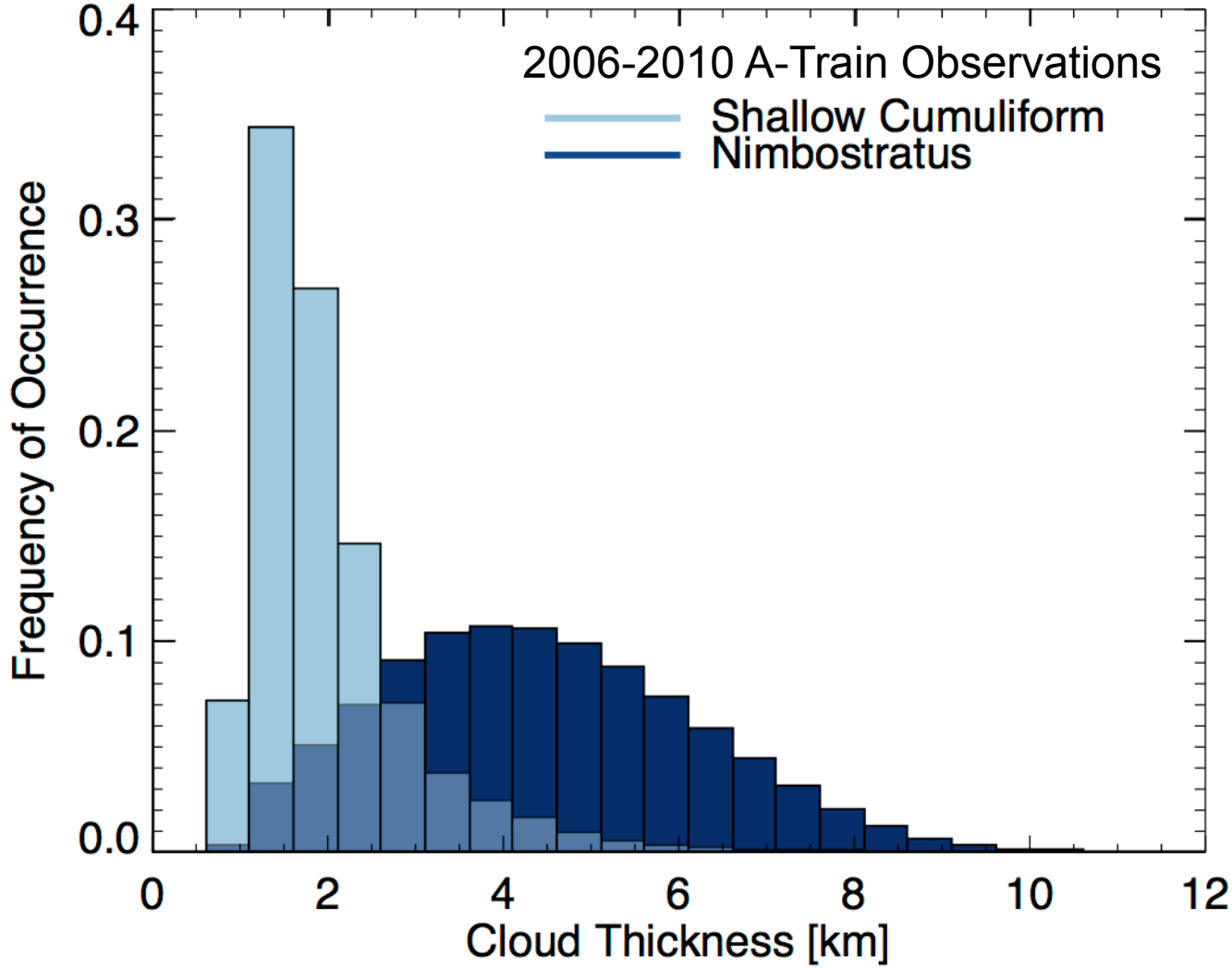
Department of Meteorology, University of Utah, Salt Lake City, Utah



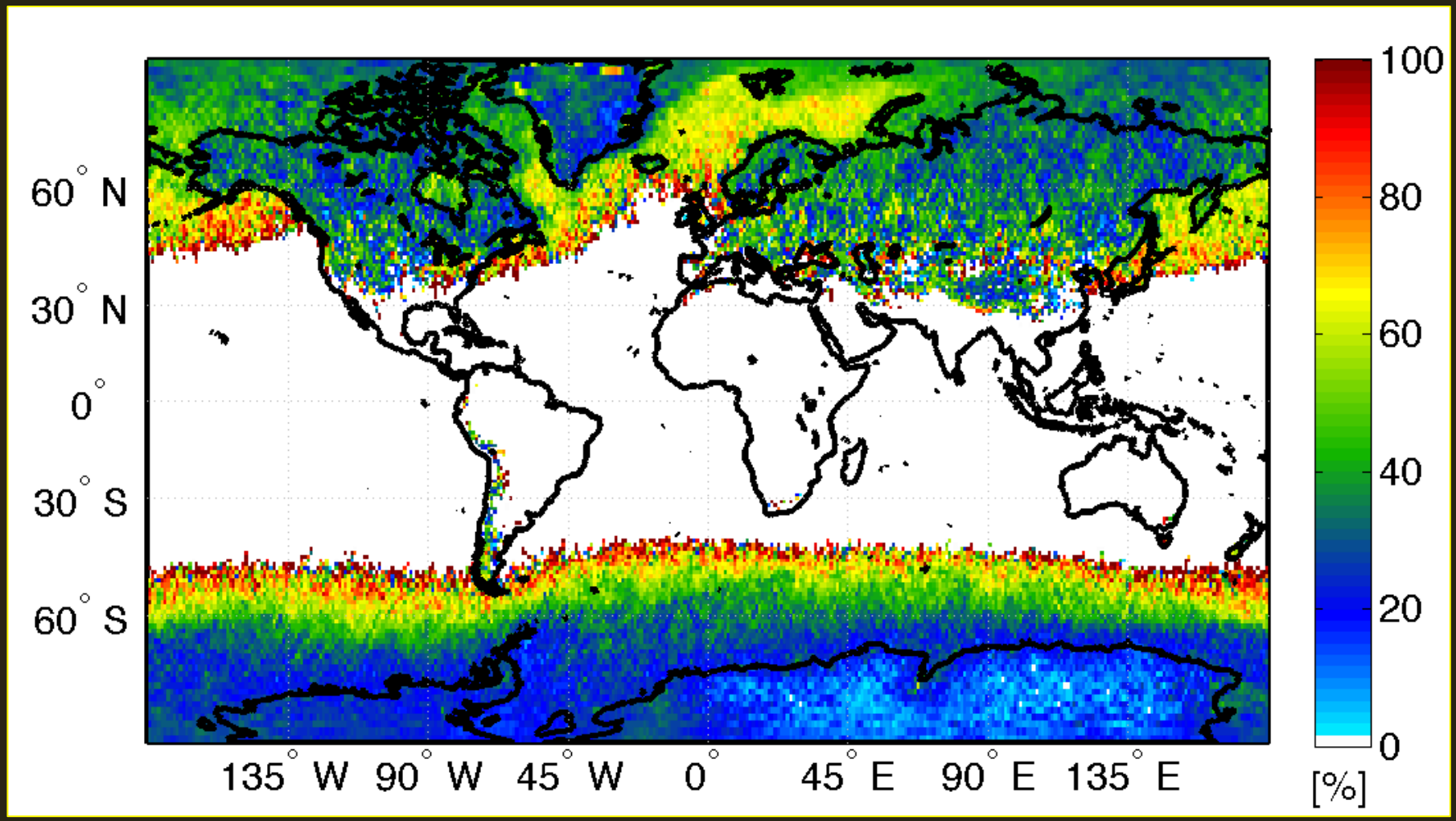
Convective Snow (Pre-GPM)

- How shallow?
- Where?
- Radiometric signatures?
- Environmental conditions (TPW/T_2m)?

Cloud Thickness – Cumuliform Snow



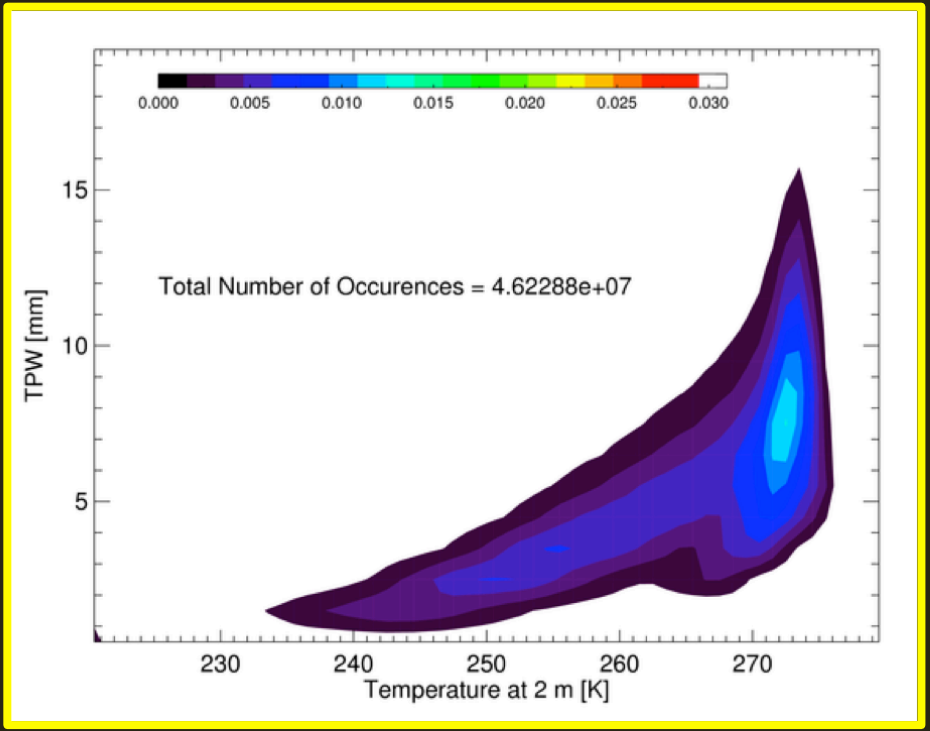
Shallow Snowfall Fraction



(Fraction = % of total snowfall occurrences)

Kulie et al. (2015): A Shallow Snowfall Census Using Spaceborne Radar. *Submitted J. Hydrometeor.*

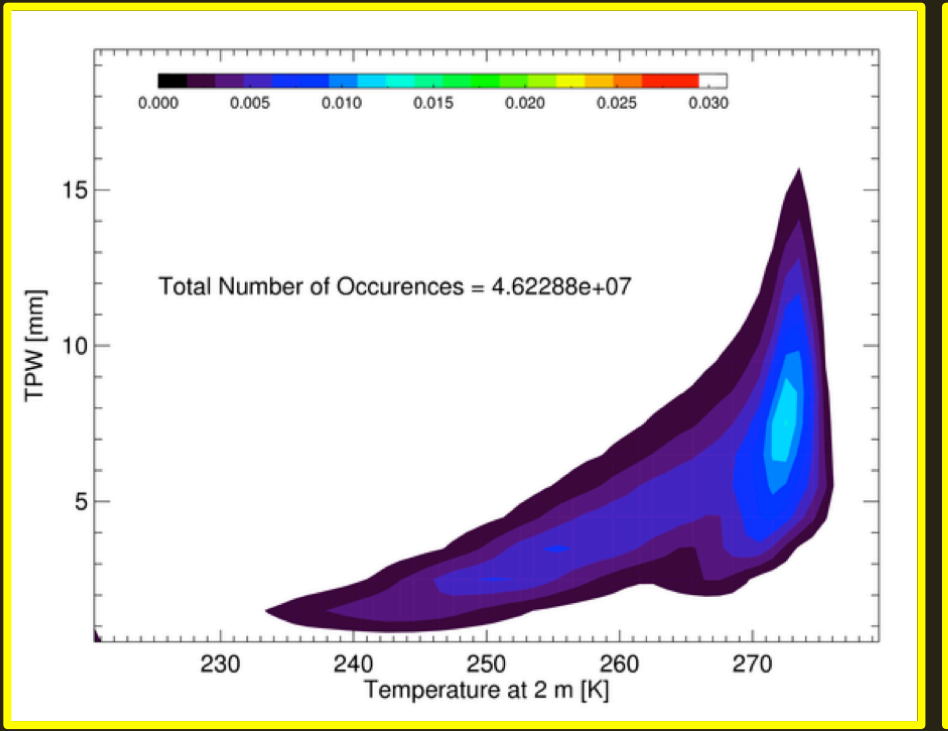
Global Snowfall: TPW/T_2m



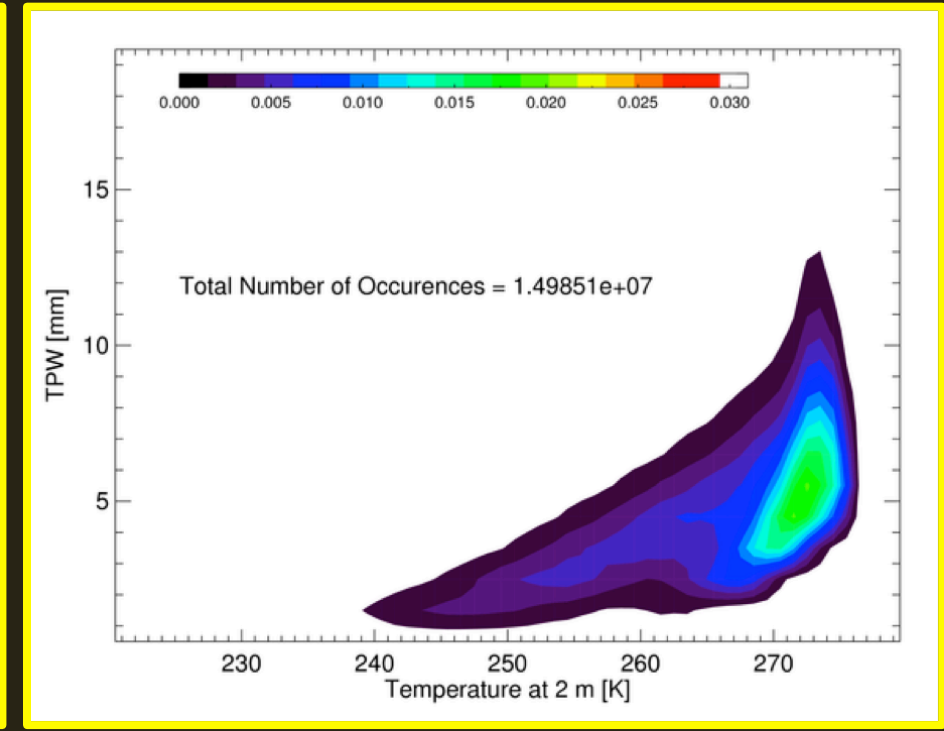
All Snowfall Events

GPROF V1.4: Cold surface (T < 255 K) a priori database

Global Snowfall: TPW/T_2m



All Snowfall Events

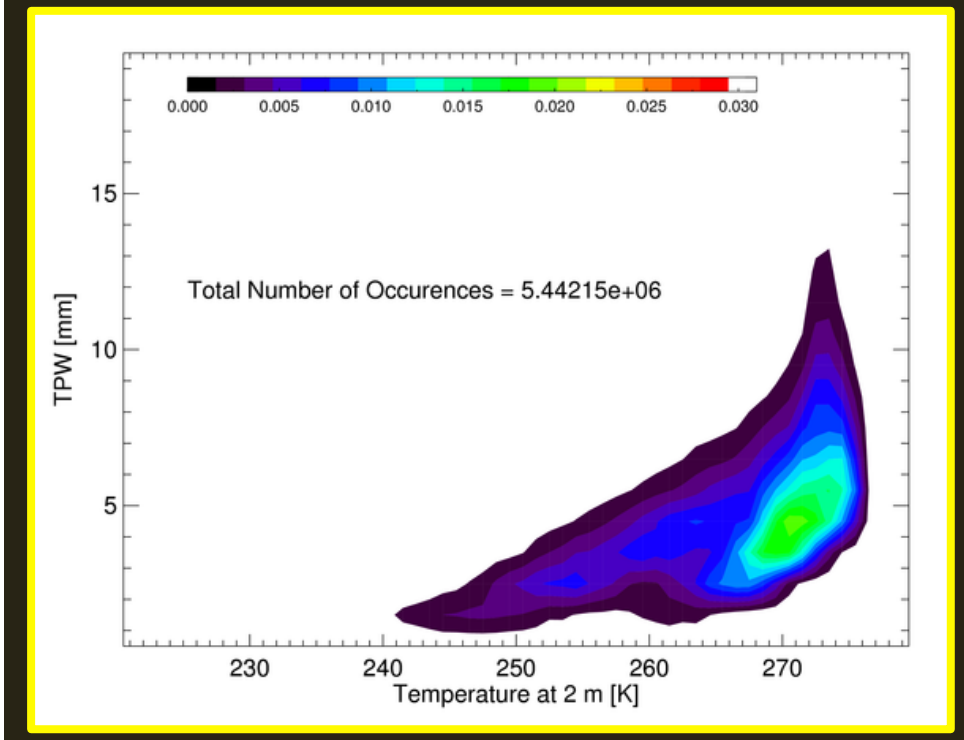


Shallow Snowfall Events

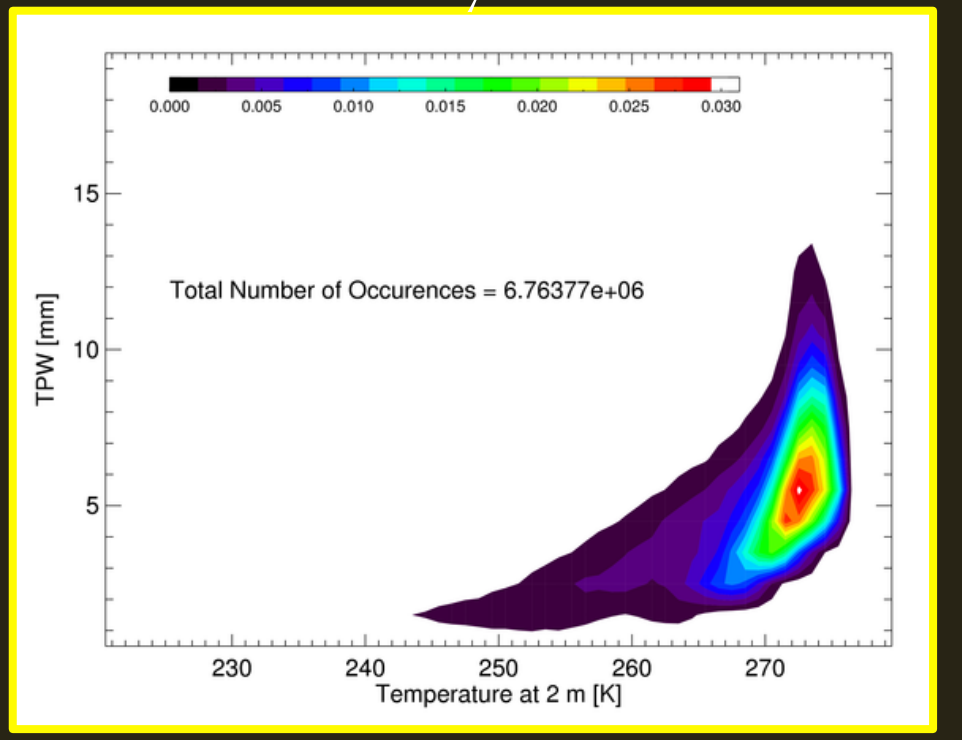
GPROF V1.4: Cold surface (T < 255 K) a priori database

Global Snowfall: TPW/T_2m

Shallow Cumuliform Snowfall Only

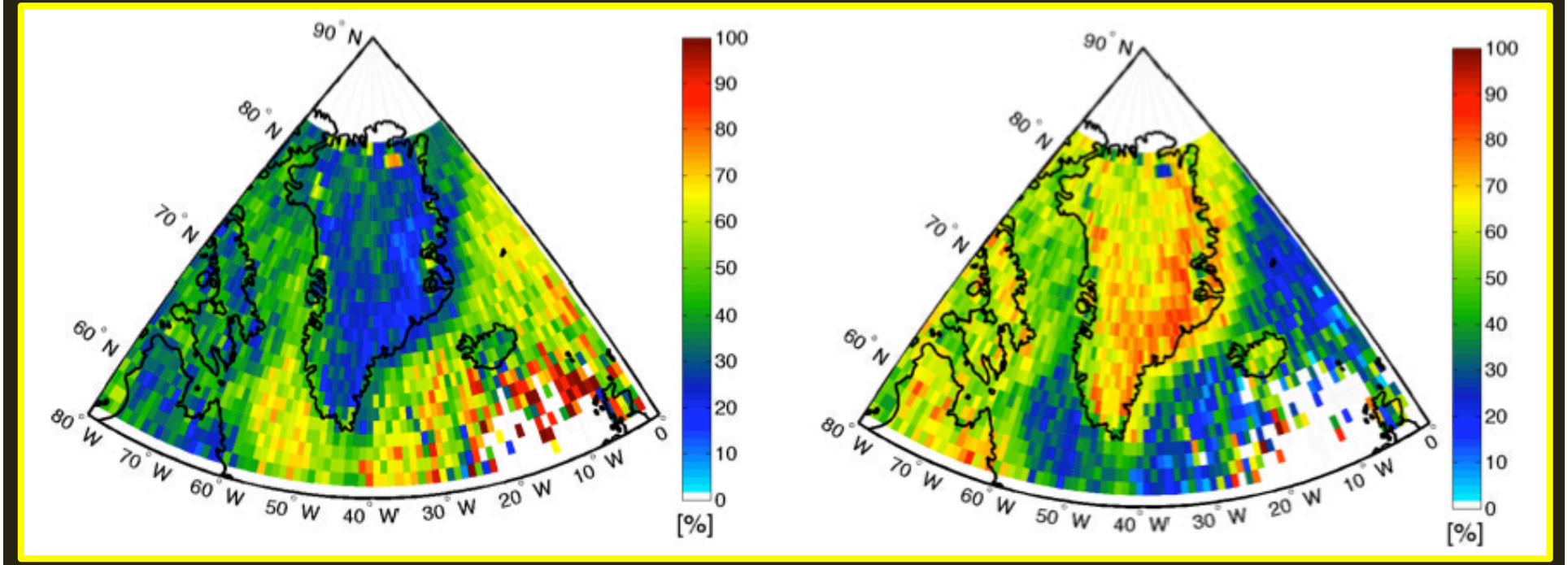


Northern Hemisphere



Southern Hemisphere

Convective Snow: Radiometer Perspective

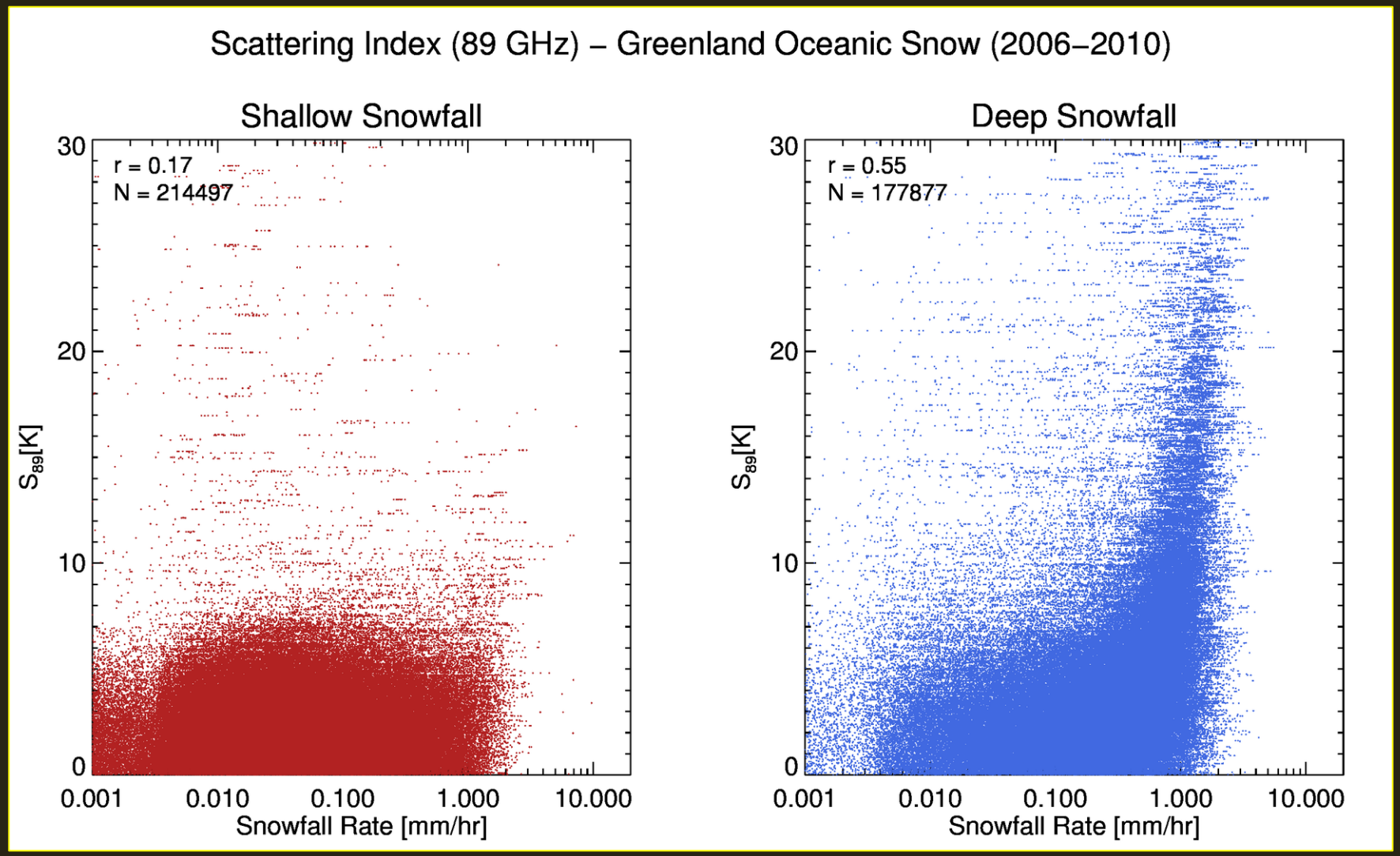


Shallow Cumuliform Fraction

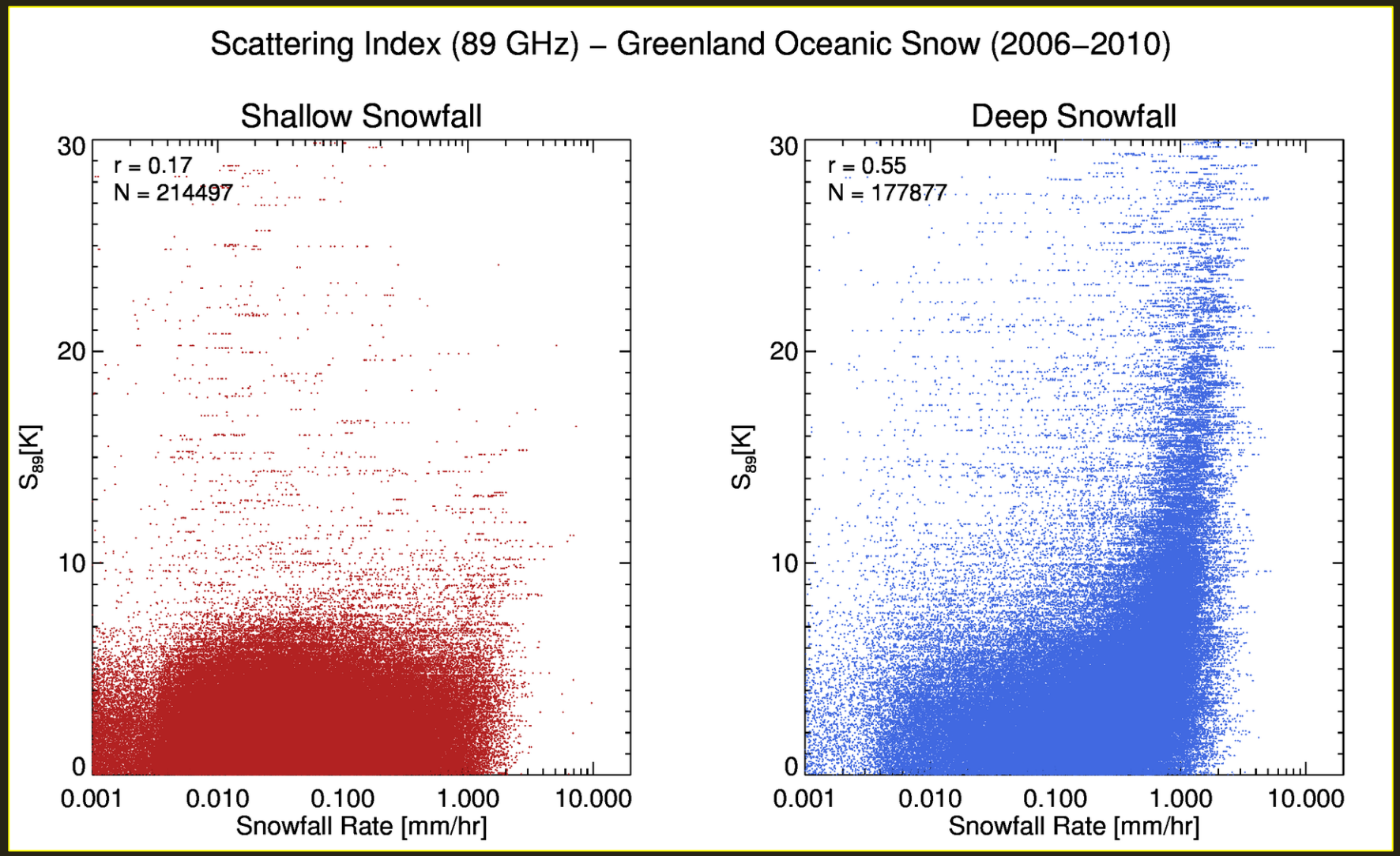
Deeper Nimbostratus Fraction

Unique Radiometric Signatures?
Greenland/N. Atlantic Ocean Focus

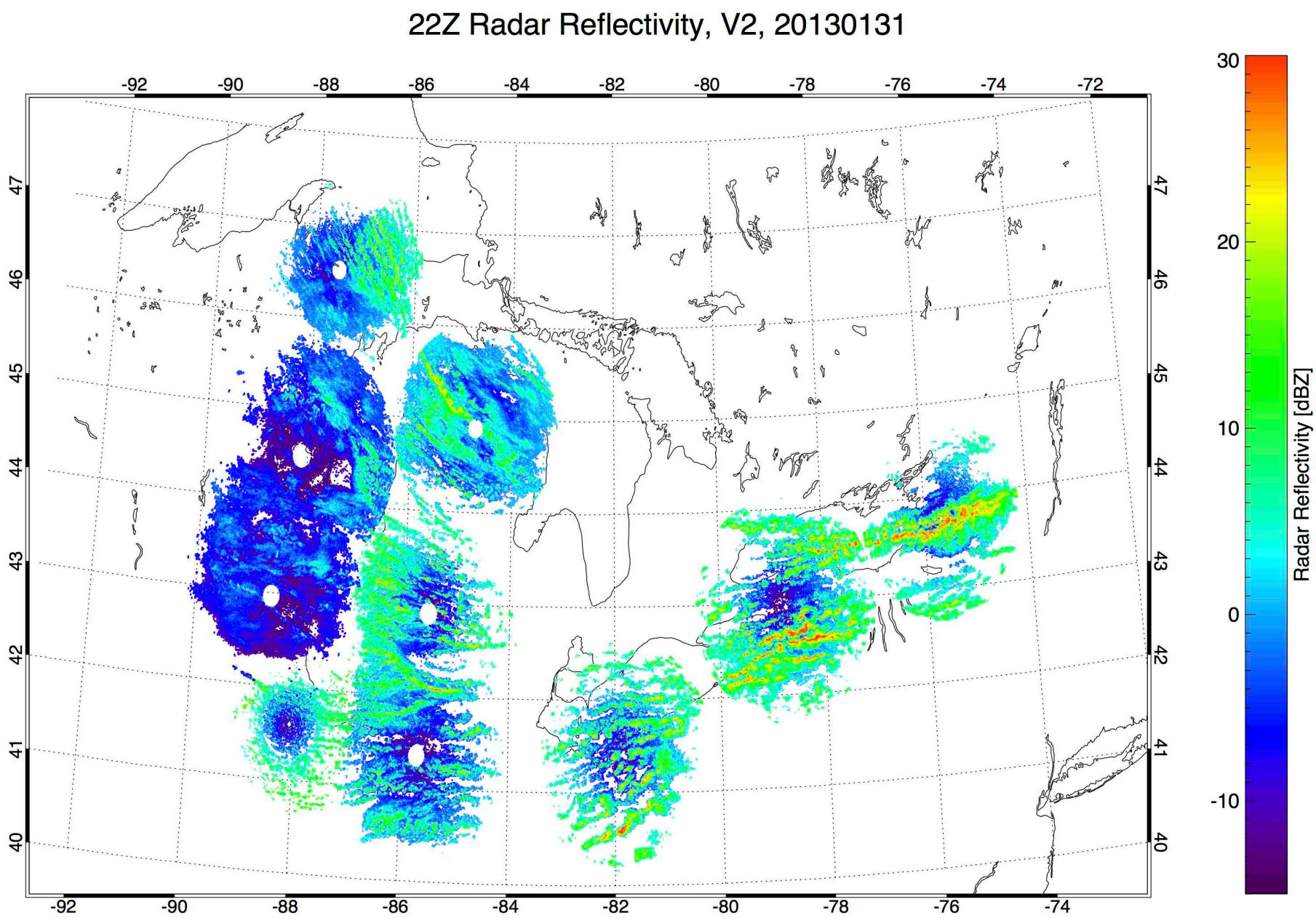
Convective Snow: Radiometer Perspective



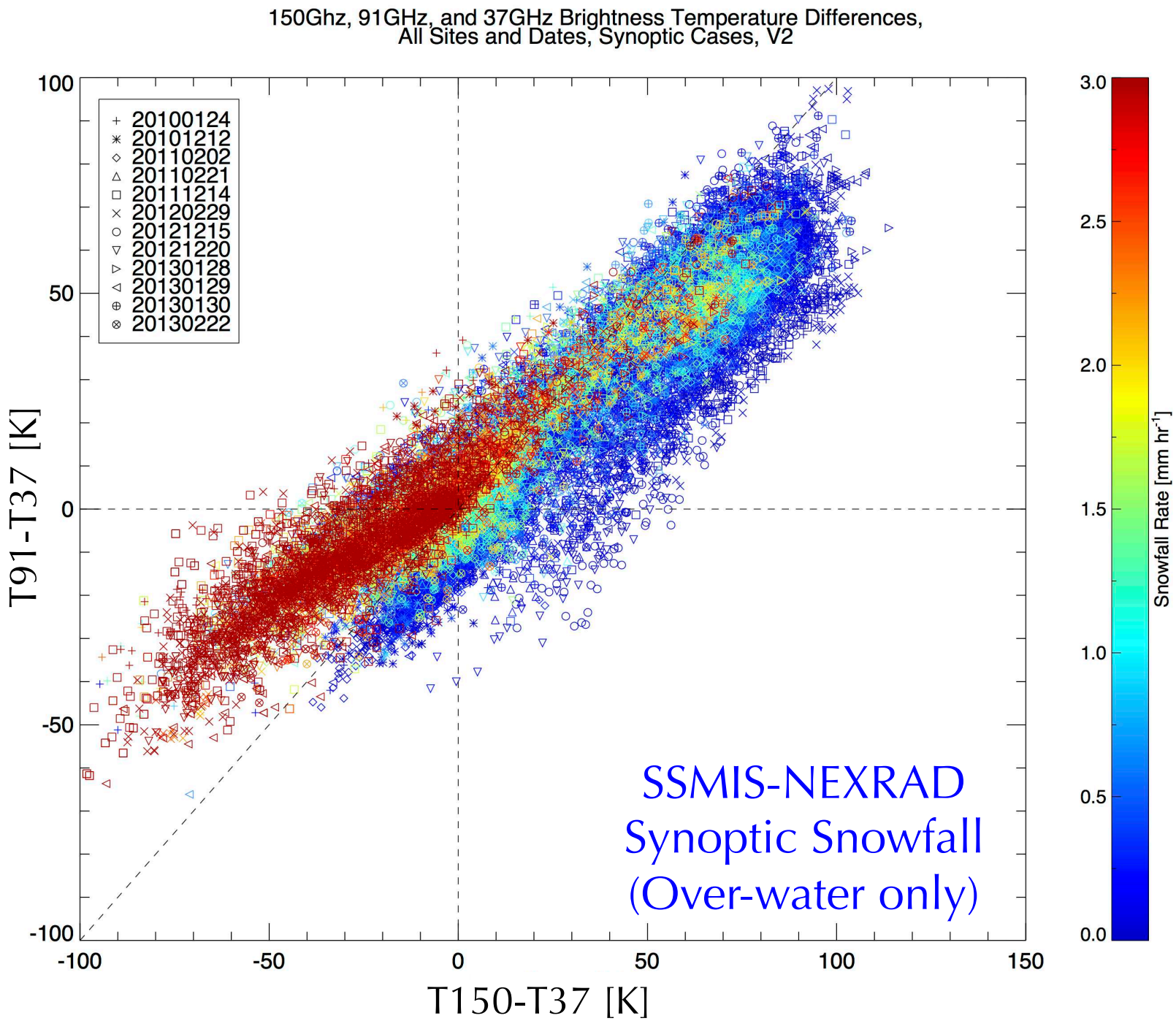
Convective Snow: Radiometer Perspective

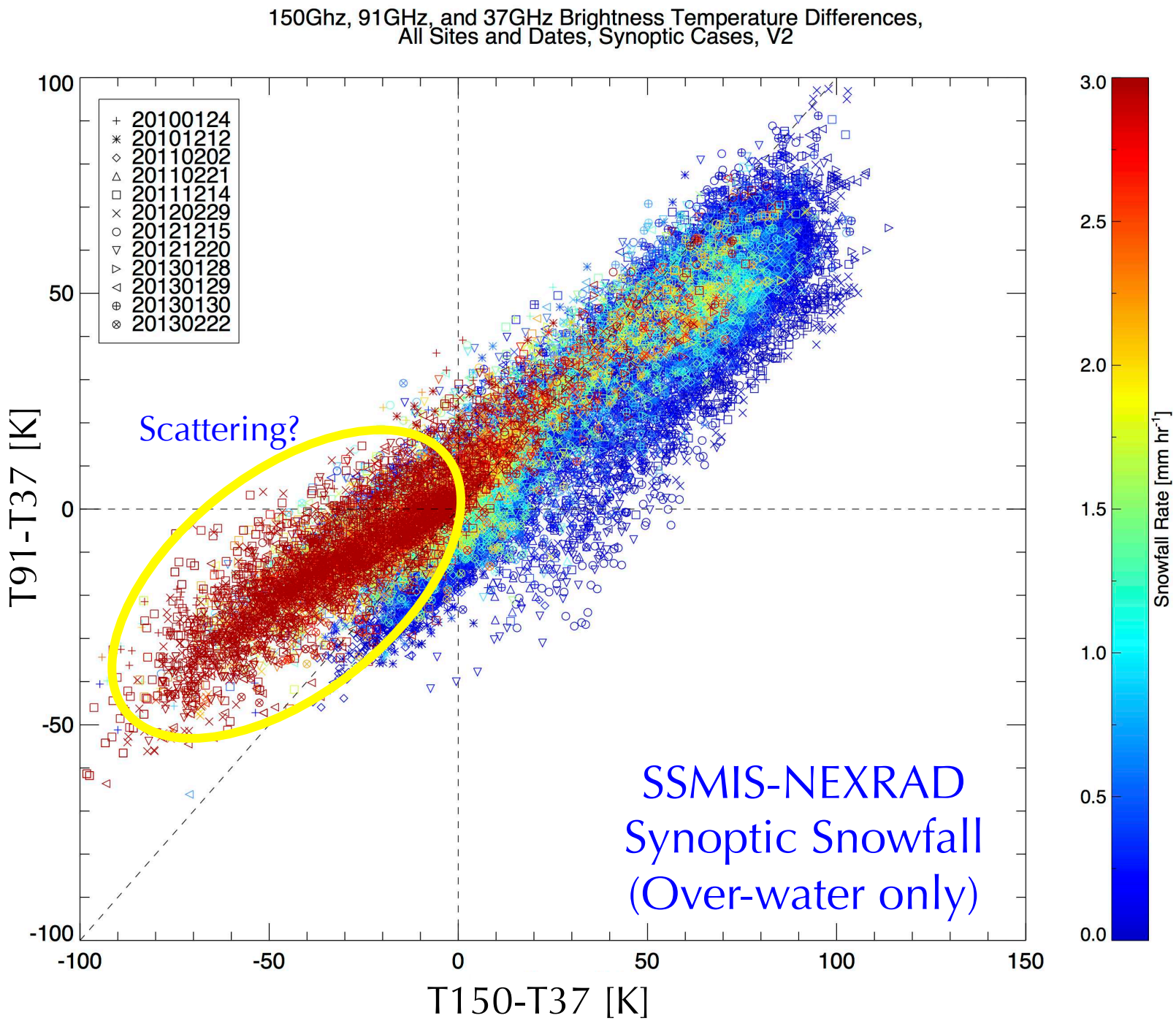


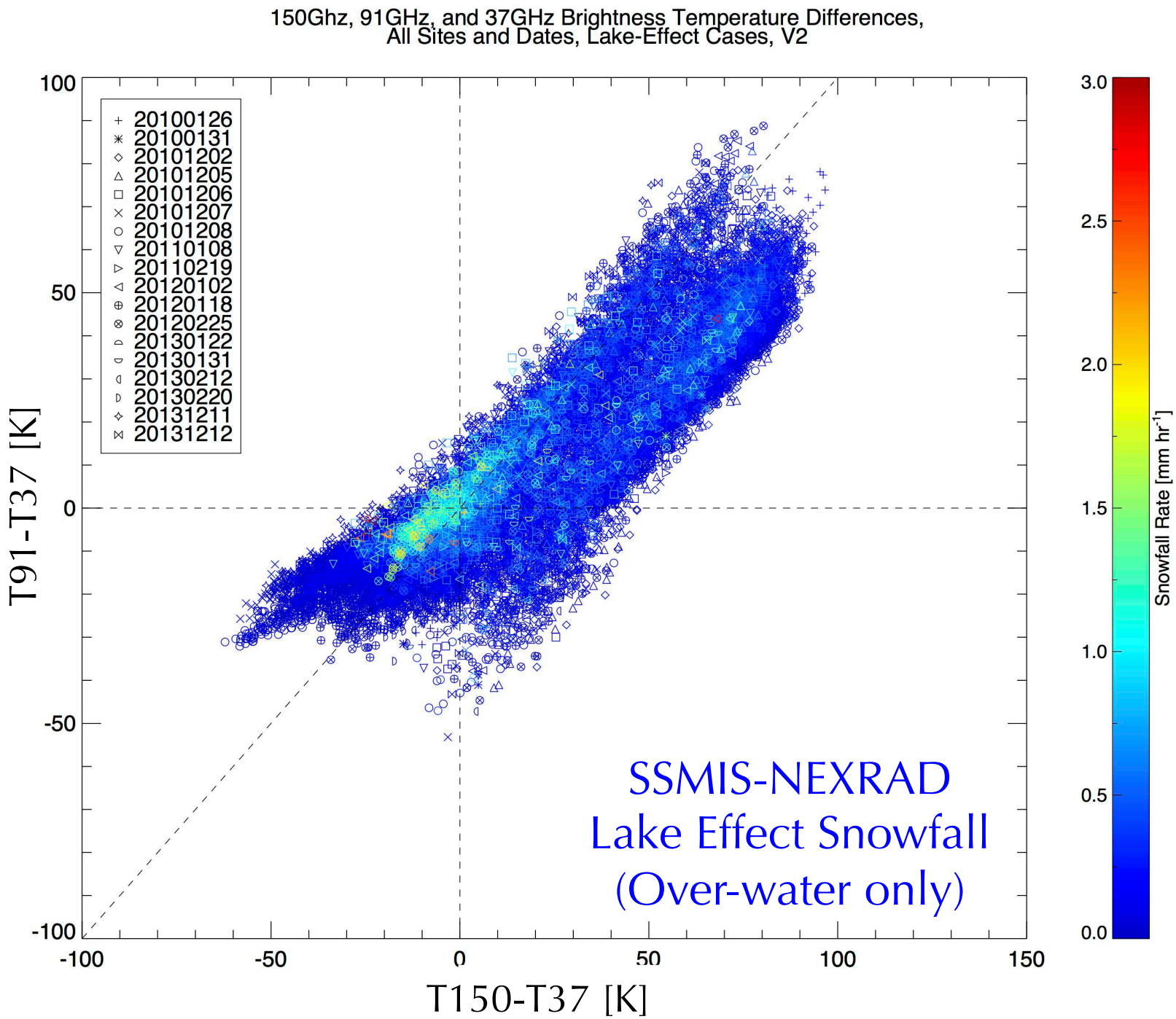
Higher Frequency Scattering?
SSMIS + NEXRAD, GPM + NEXRAD

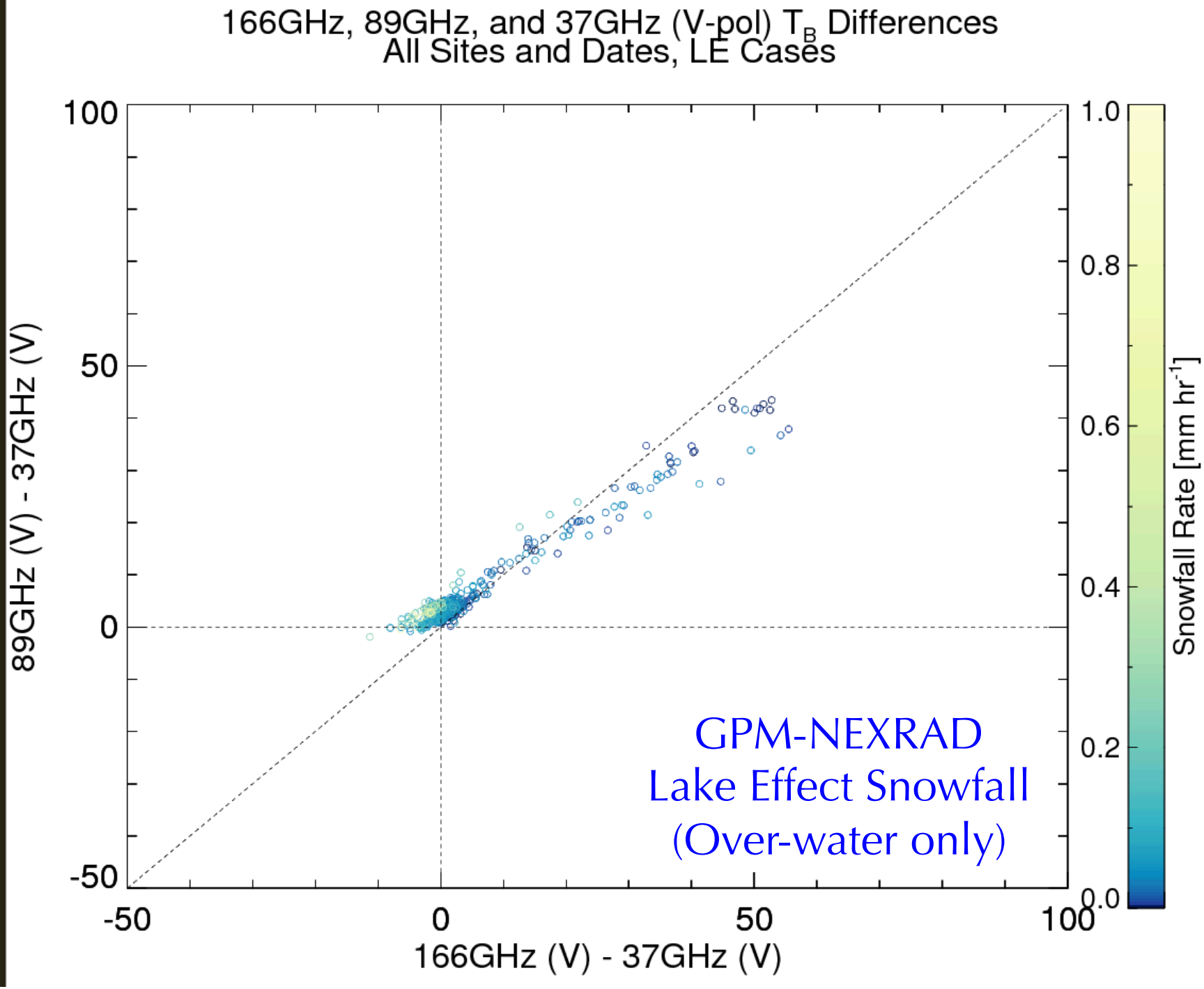


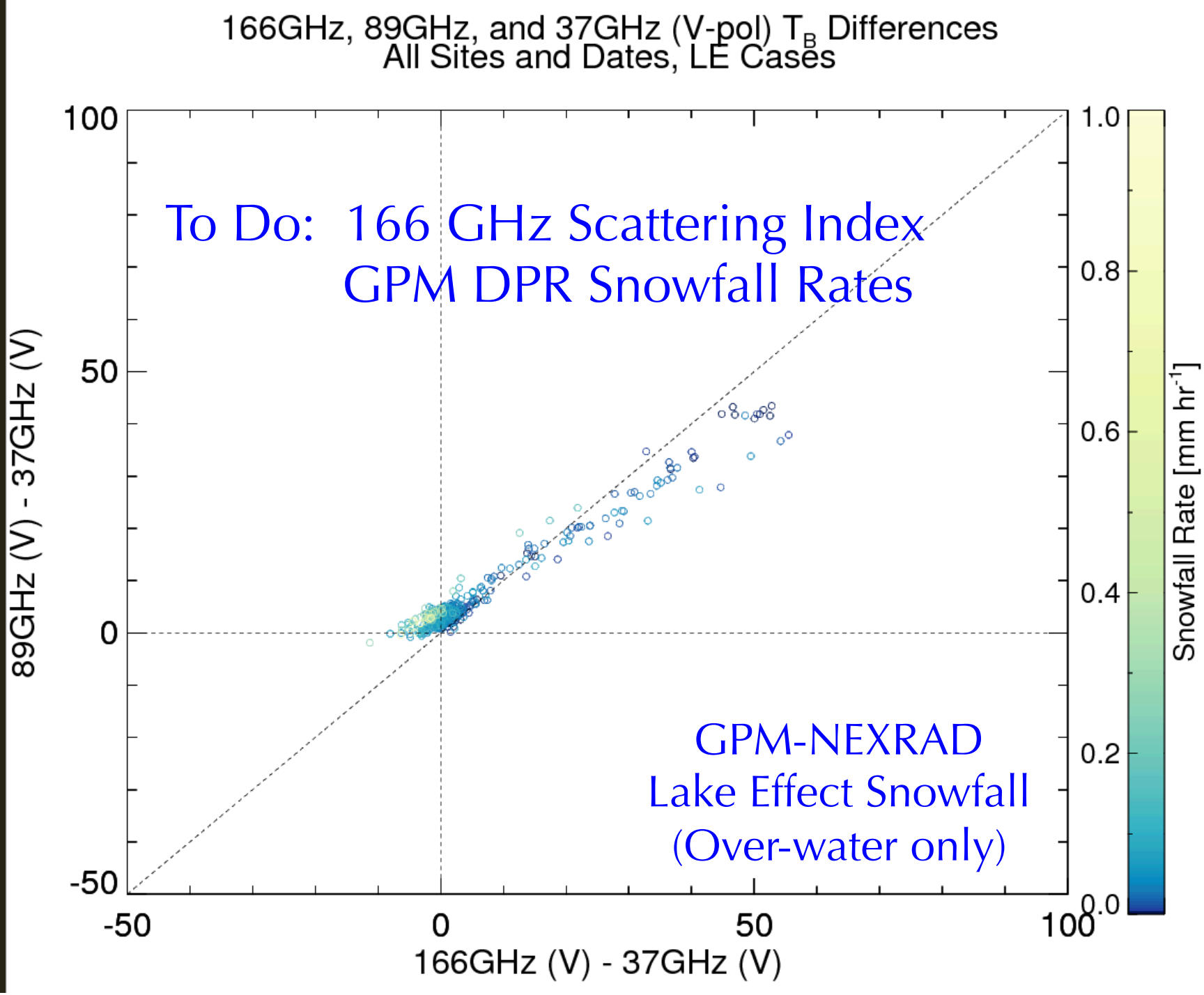
NEXRAD Composite


150Ghz, 91GHz, and 37GHz Brightness Temperature Differences,
All Sites and Dates, Synoptic Cases, V2
20100124
20101212
20110202
20110221
20111214
20120229
20121215
20121220
20130128
20130129
20130130
20130222
T91-T37 [K]
T150-T37 [K]
Snowfall Rate [mm hr-1]
SSMIS-NEXRAD
Synoptic Snowfall
(Over-water only)


150Ghz, 91GHz, and 37GHz Brightness Temperature Differences,
All Sites and Dates, Synoptic Cases, V2
20100124
20101212
20110202
20110221
20111214
20120229
20121215
20121220
20130128
20130129
20130130
20130222
Scattering?
SSMIS-NEXRAD
Synoptic Snowfall
(Over-water only)
T91-T37 [K]
T150-T37 [K]
Snowfall Rate [mm hr-1]
100
50
0
-50
-100
-100
-50
0
50
100
150
3.0
2.5
2.0
1.5
1.0
0.5
0.0

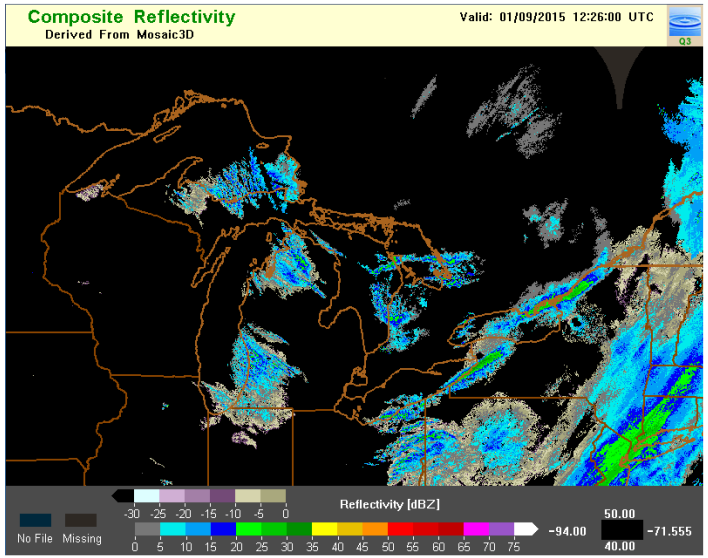

150Ghz, 91GHz, and 37GHz Brightness Temperature Differences,
All Sites and Dates, Lake-Effect Cases, V2
20100126
20100131
20101202
20101205
20101206
20101207
20101208
20110108
20110219
20120102
20120118
20120225
20130122
20130131
20130212
20130220
20131211
20131212
T91-T37 [K]
T150-T37 [K]
Snowfall Rate [mm hr-1]
SSMIS-NEXRAD
Lake Effect Snowfall
(Over-water only)

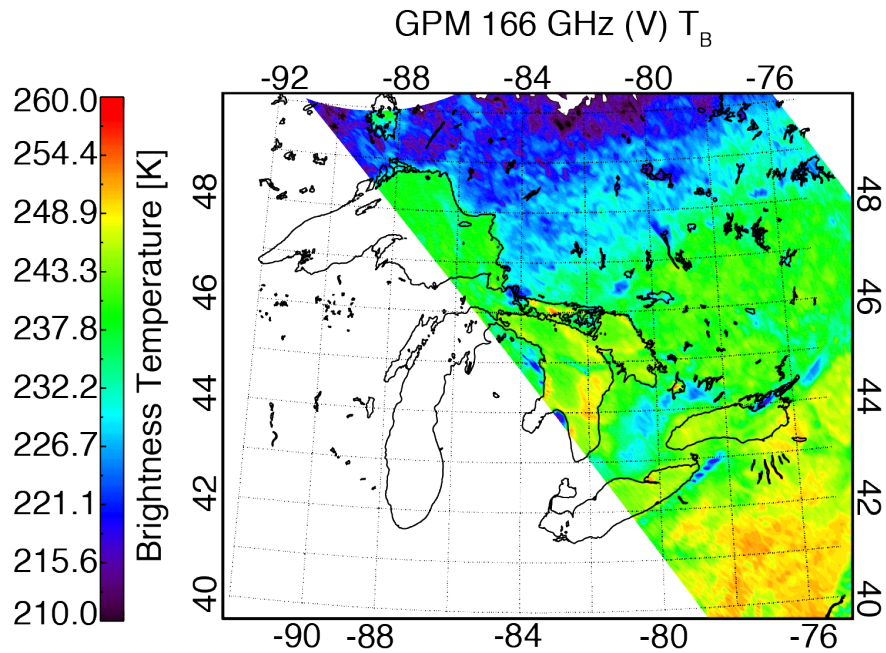

166GHz, 89GHz, and 37GHz (V-pol) T_B Differences
All Sites and Dates, LE Cases
89GHz (V) - 37GHz (V)
166GHz (V) - 37GHz (V)
Snowfall Rate [mm hr^{-1}]
100
50
0
-50
-50
0
50
100
1.0
0.8
0.6
0.4
0.2
0.0
GPM-NEXRAD
Lake Effect Snowfall
(Over-water only)

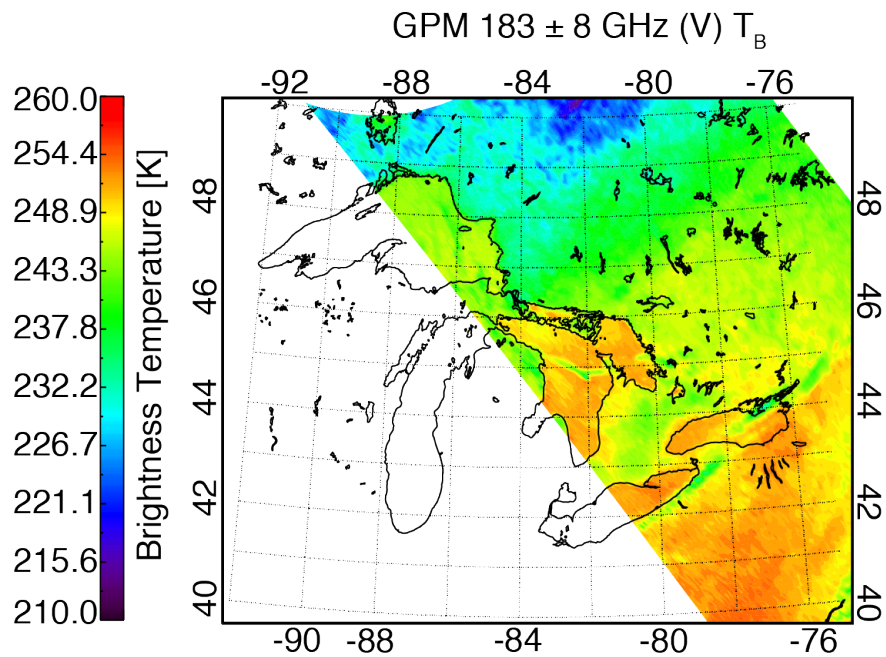

166GHz, 89GHz, and 37GHz (V-pol) T_B Differences
All Sites and Dates, LE Cases
To Do: 166 GHz Scattering Index
GPM DPR Snowfall Rates
GPM-NEXRAD
Lake Effect Snowfall
(Over-water only)
89GHz (V) - 37GHz (V)
166GHz (V) - 37GHz (V)
Snowfall Rate [mm hr^{-1}]
100
50
0
-50
-50
0
50
100
1.0
0.8
0.6
0.4
0.2
0.0

166 + 183.3 GHz Information?

GPM and NEXRAD Observations
09 January 2015, 1224Z-1228Z

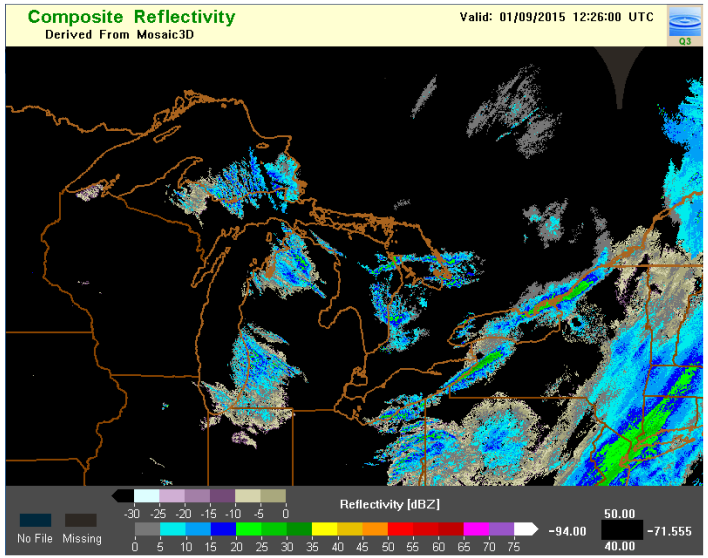


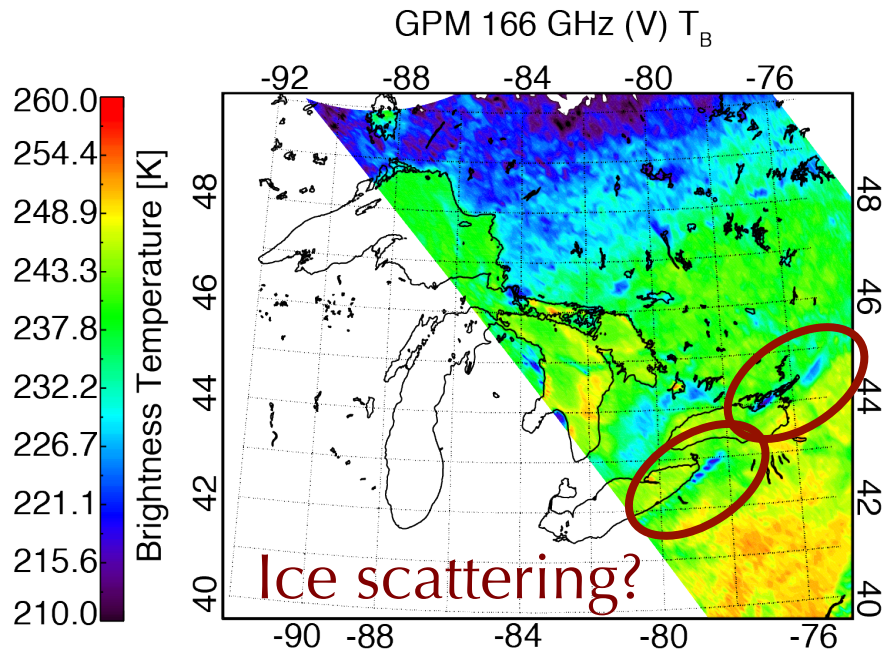


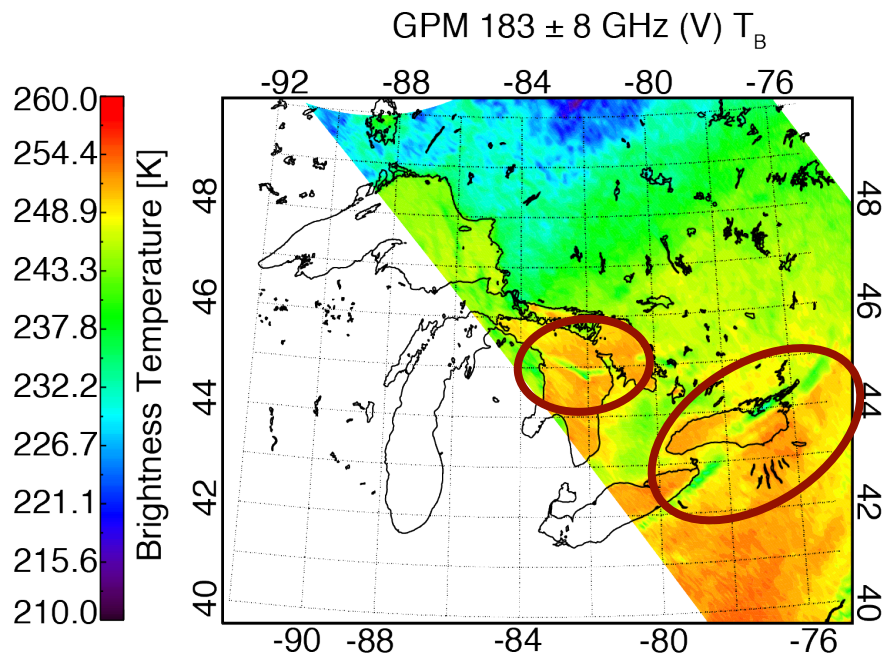


166 + 183.3 GHz Information?

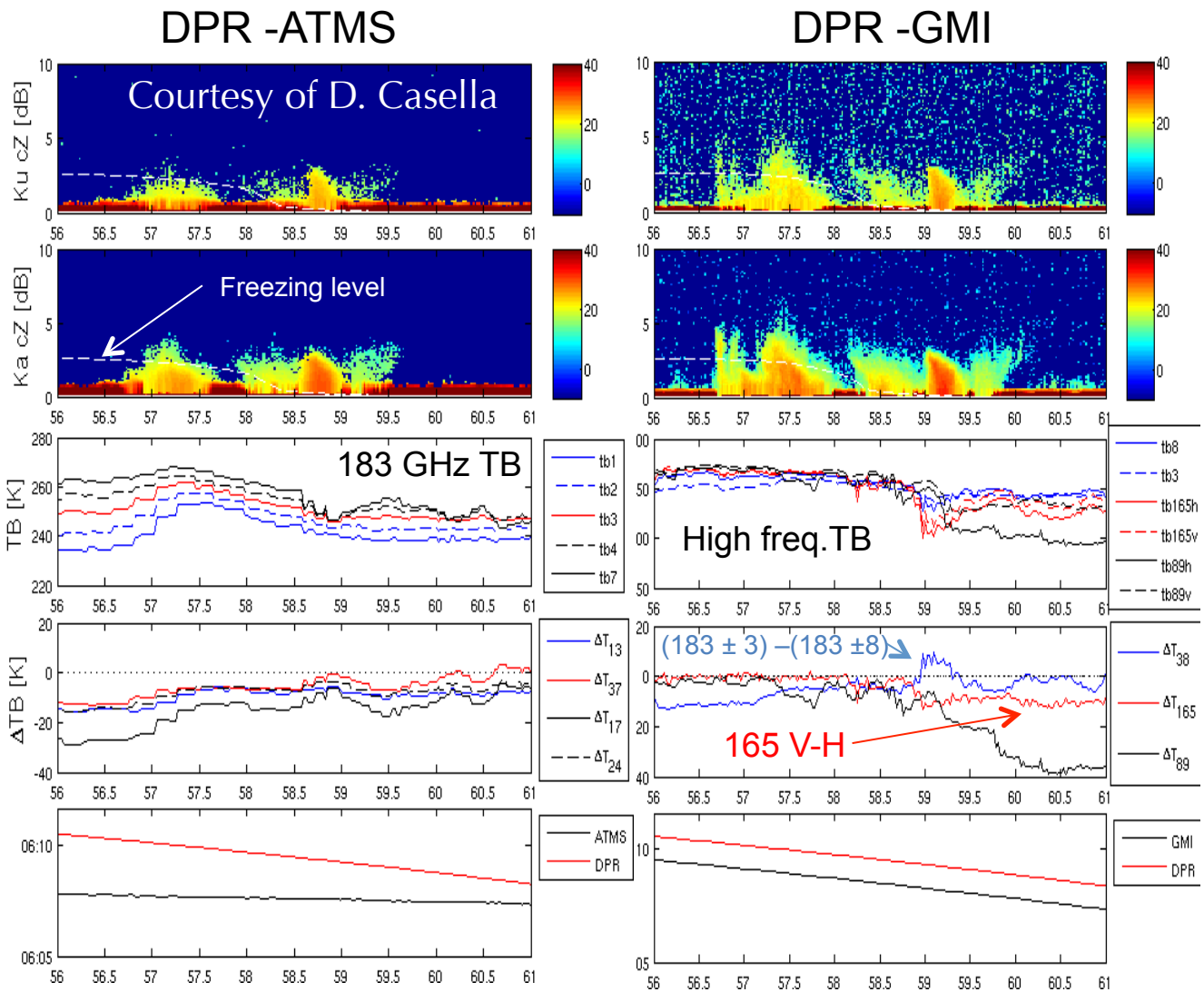
GPM and NEXRAD Observations
09 January 2015, 1224Z-1228Z



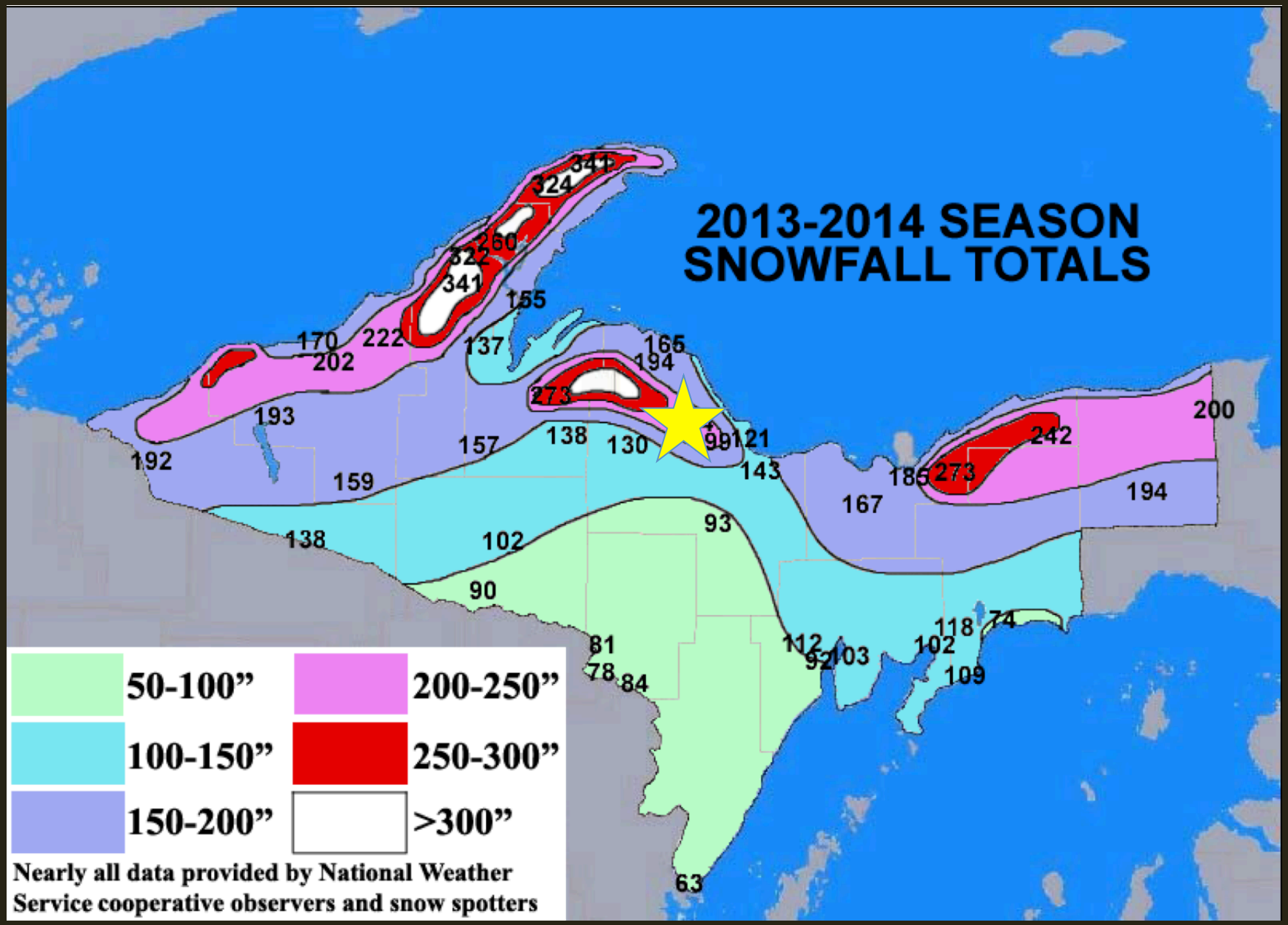




GPM Snowfall Event Near Greenland 2015/01/18



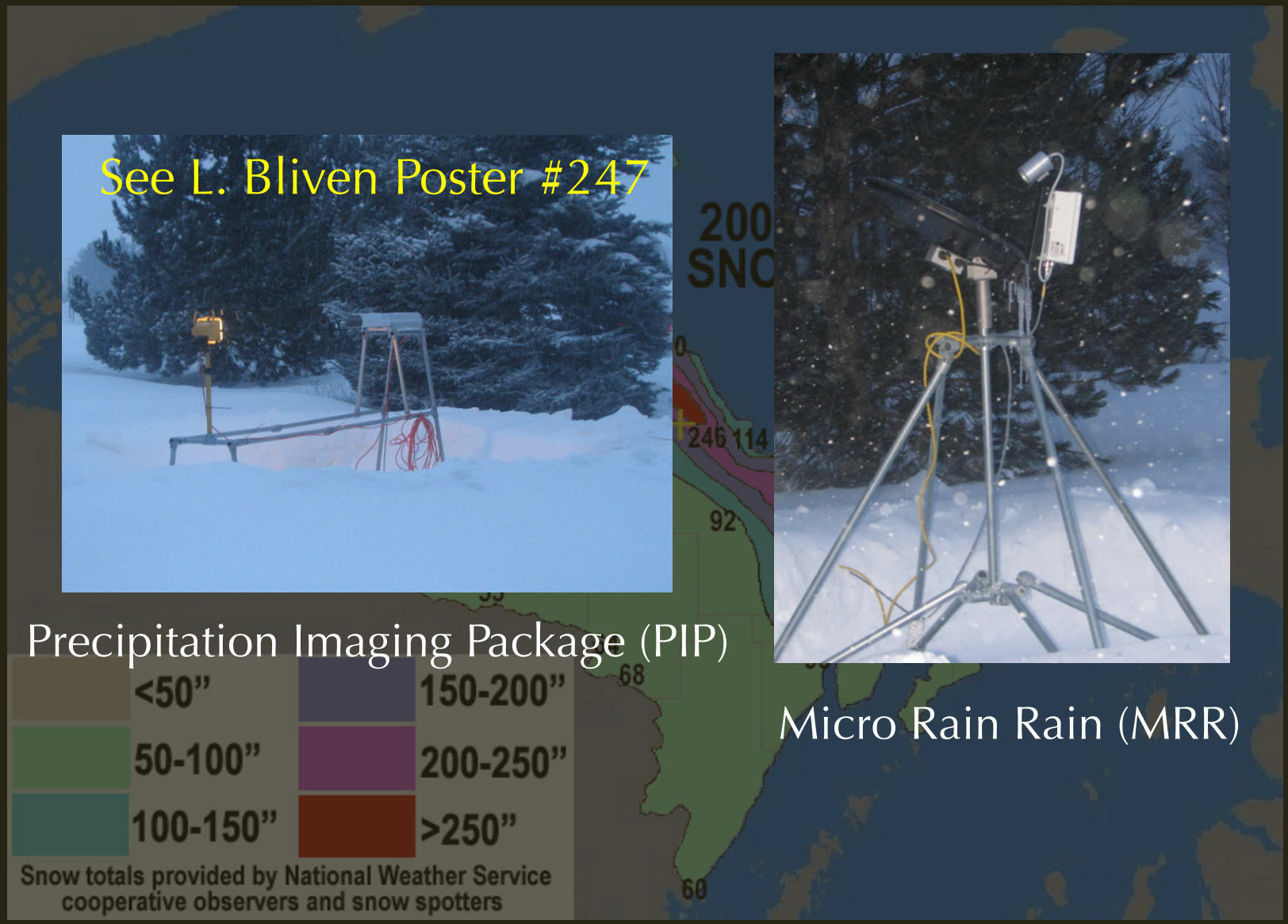
Snowfall Observatory



Snowfall Observatory

Precipitation Imaging Package (PIP)

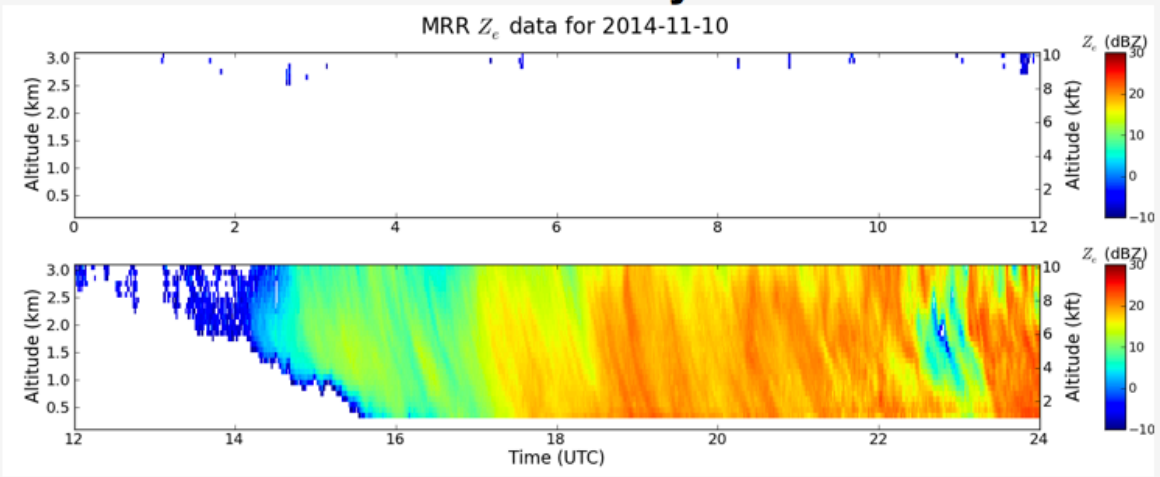
Micro Rain Rain (MRR)



“Synoptic/System” Snow– 10 Nov 2014

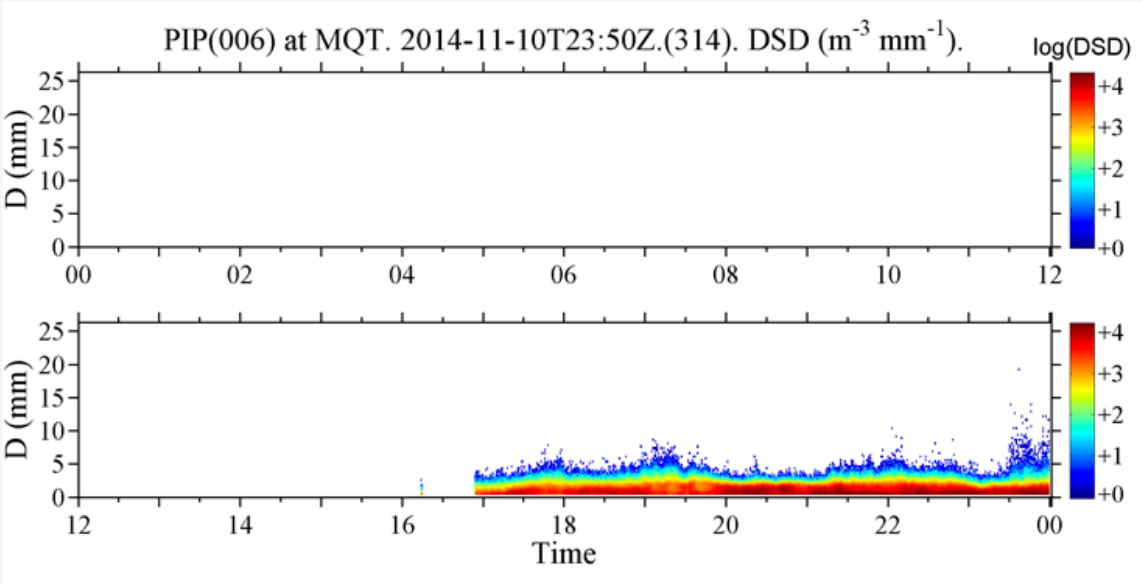
MRR

Reflectivity

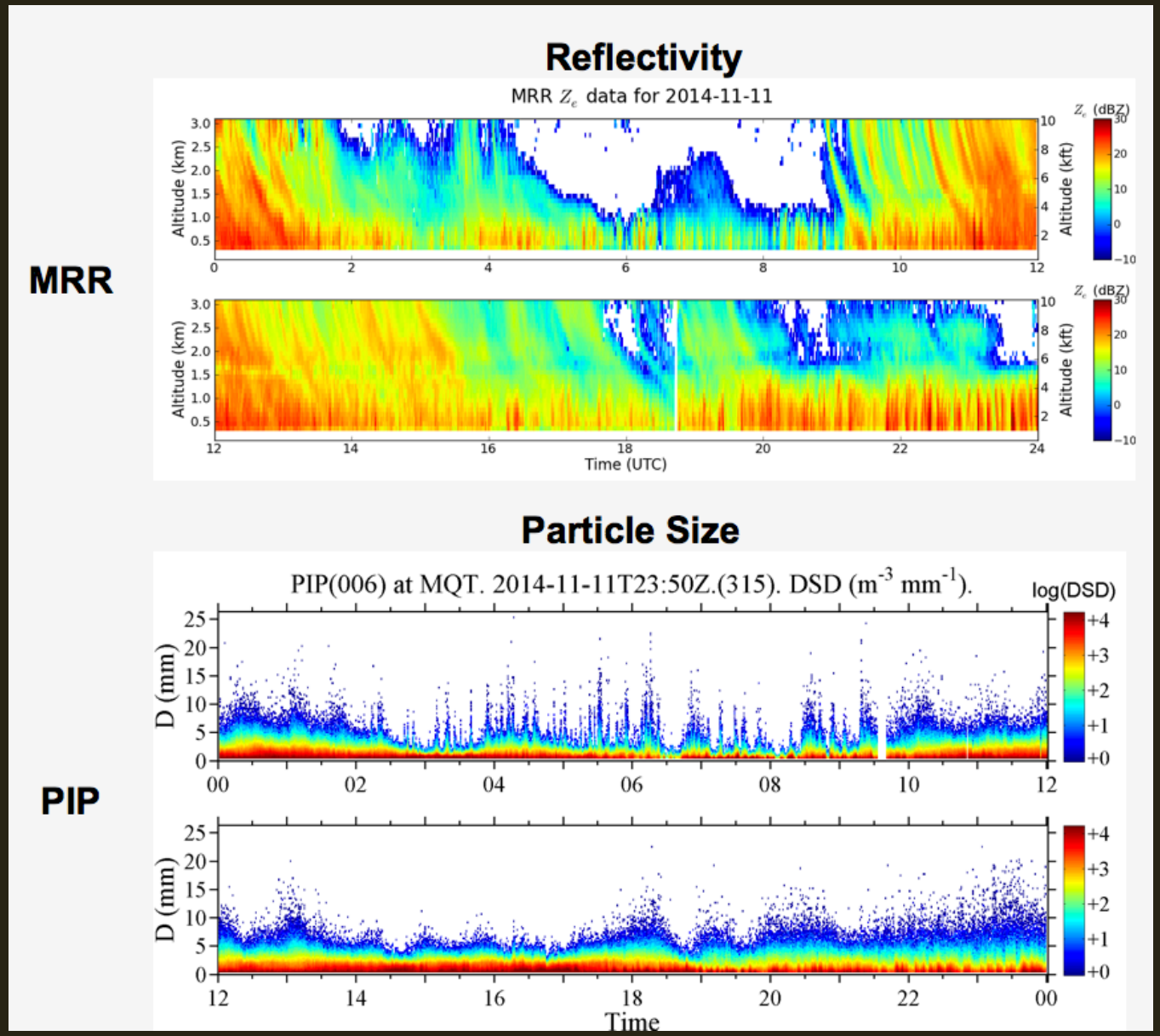


PIP

Particle Size



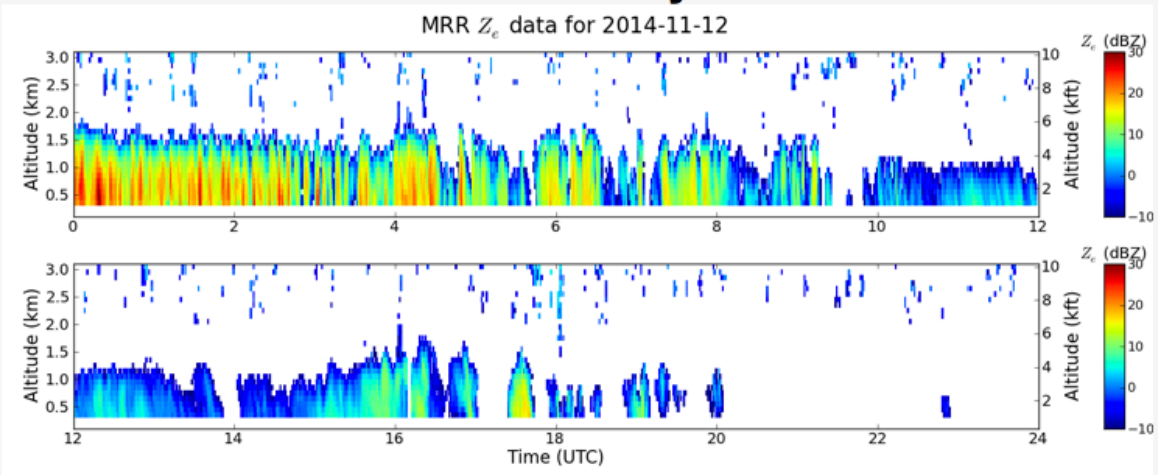
Embedded Lake-Effect Snow - 11 Nov 2014



Lake-Effect Snow - 12 Nov 2014

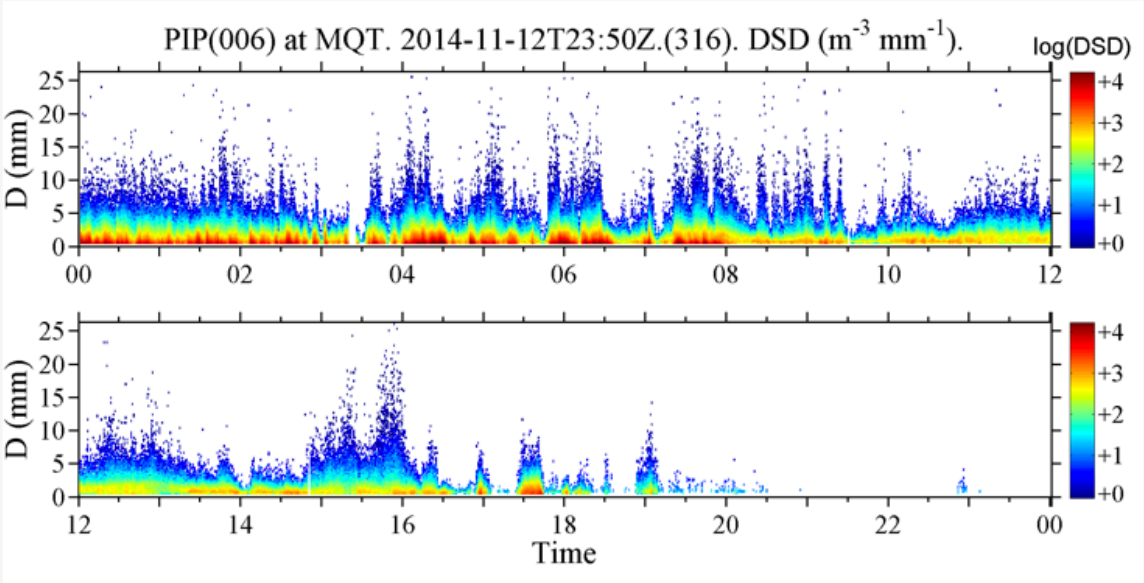
MRR

Reflectivity

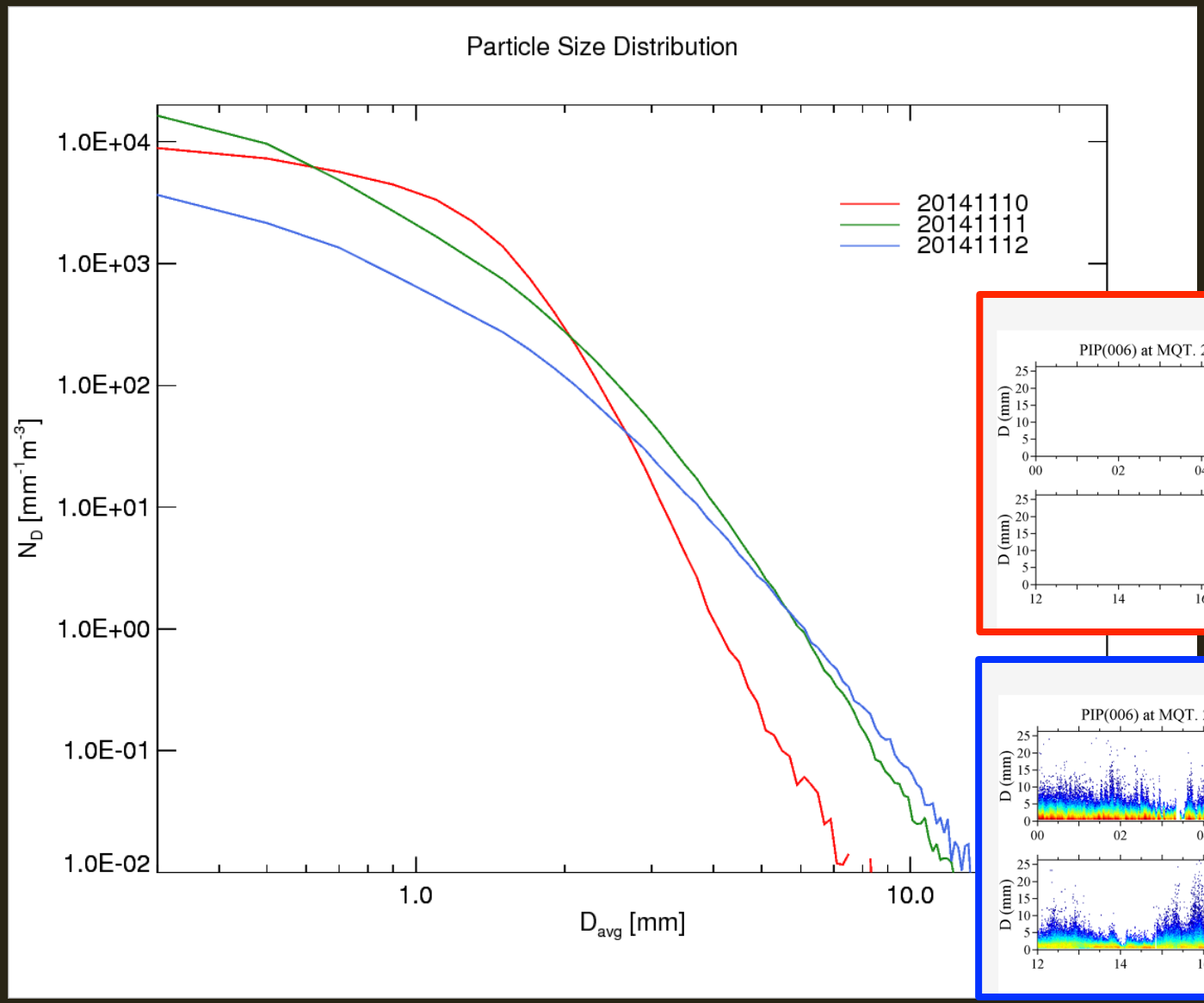


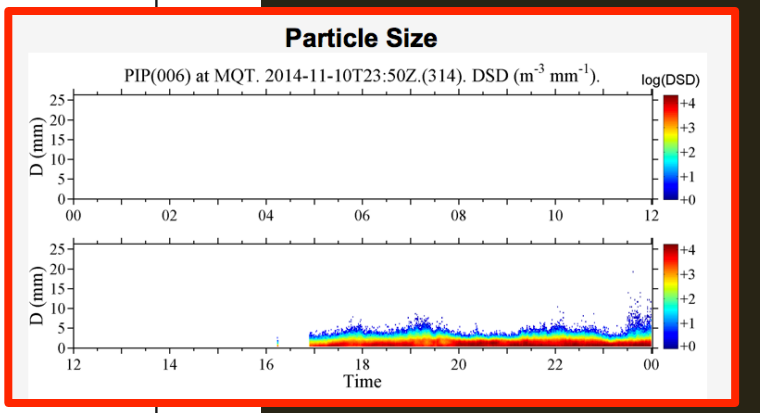
PIP

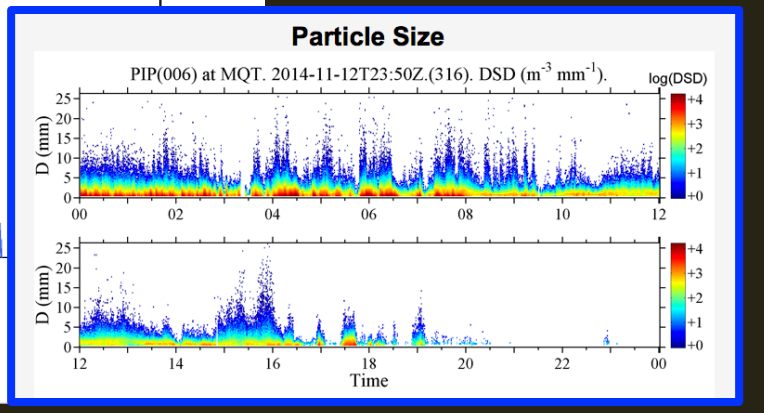
Particle Size



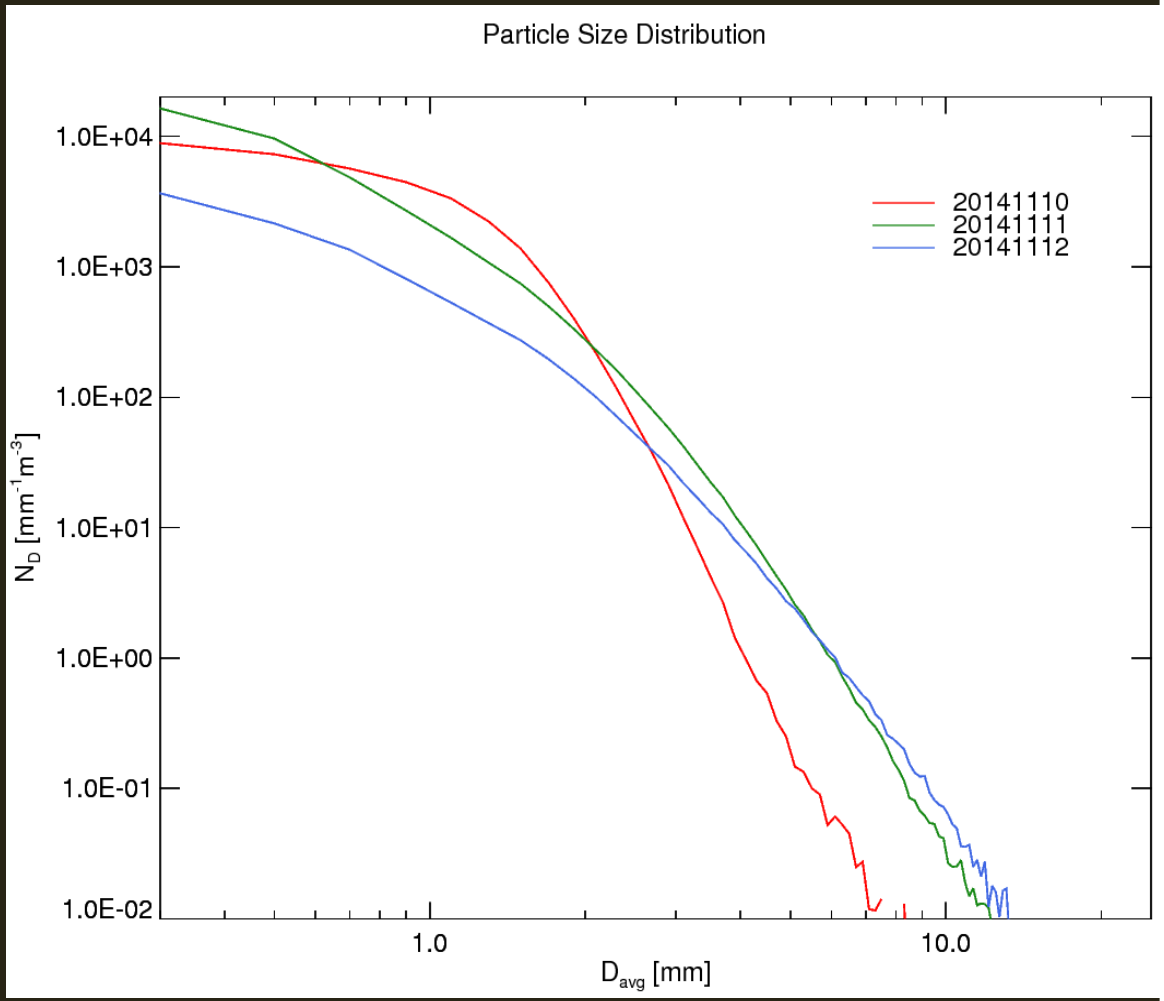
Systematic PSD Differences?

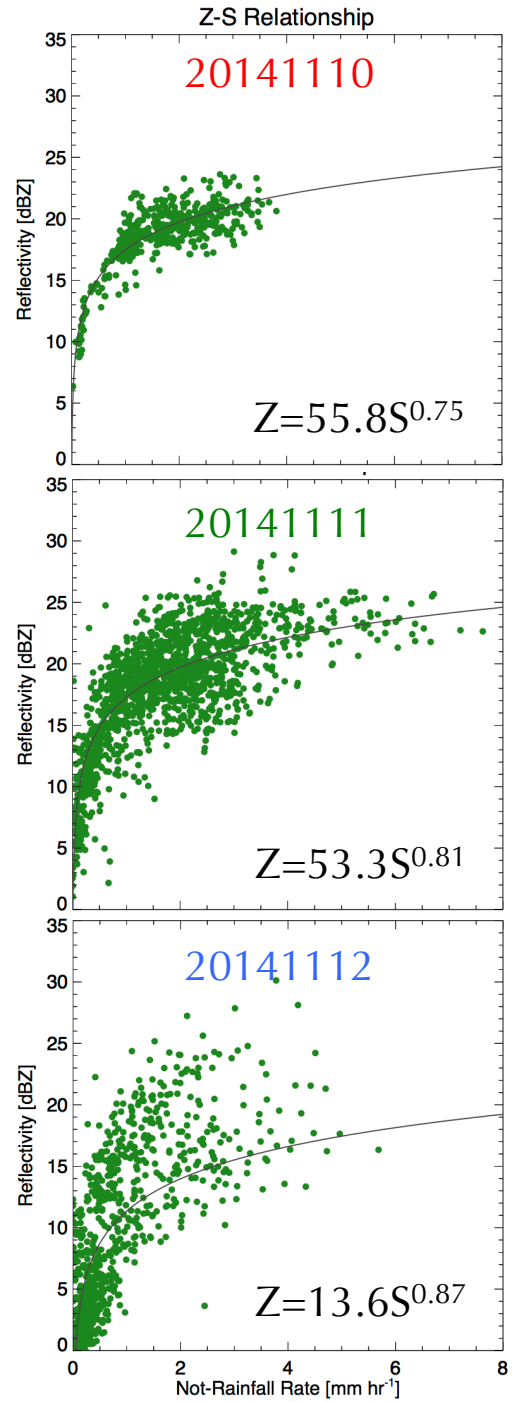


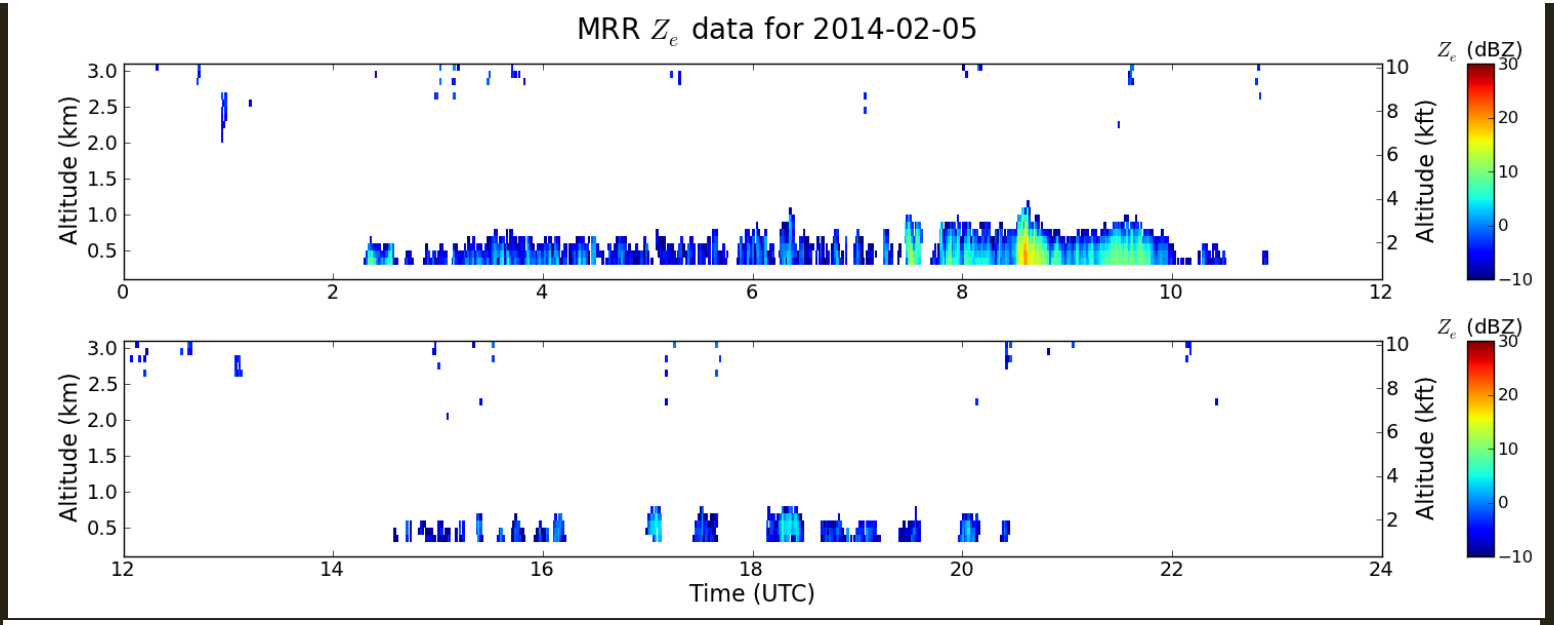


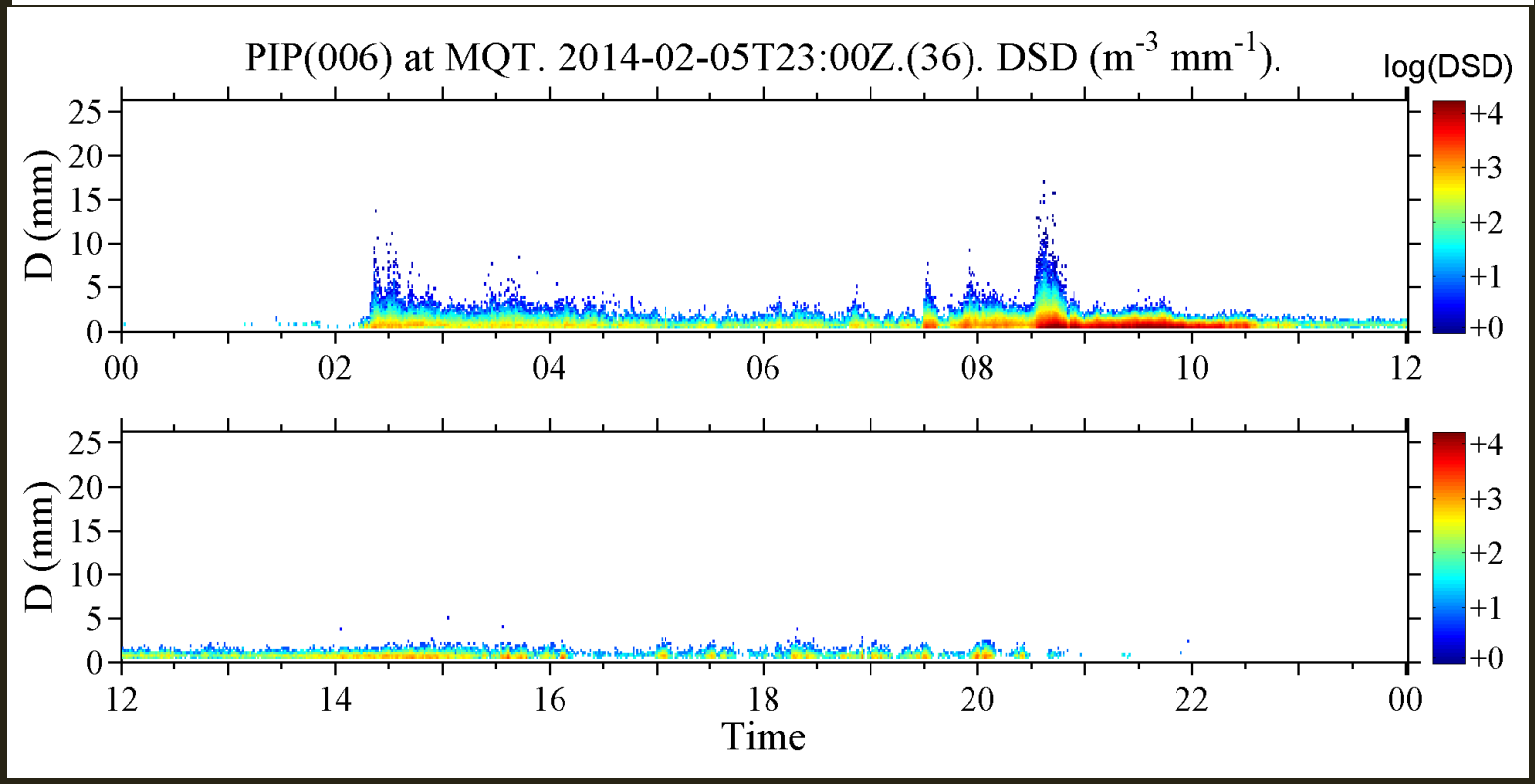


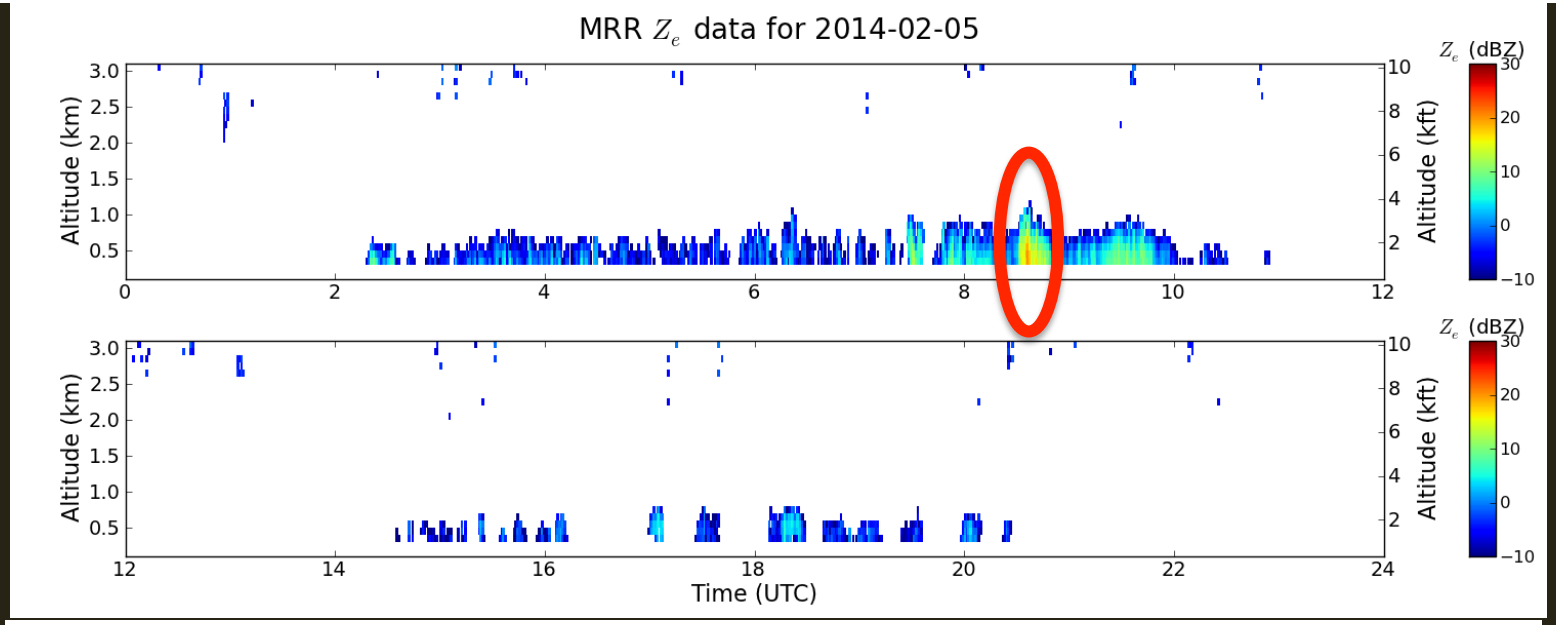
PIP/MRR

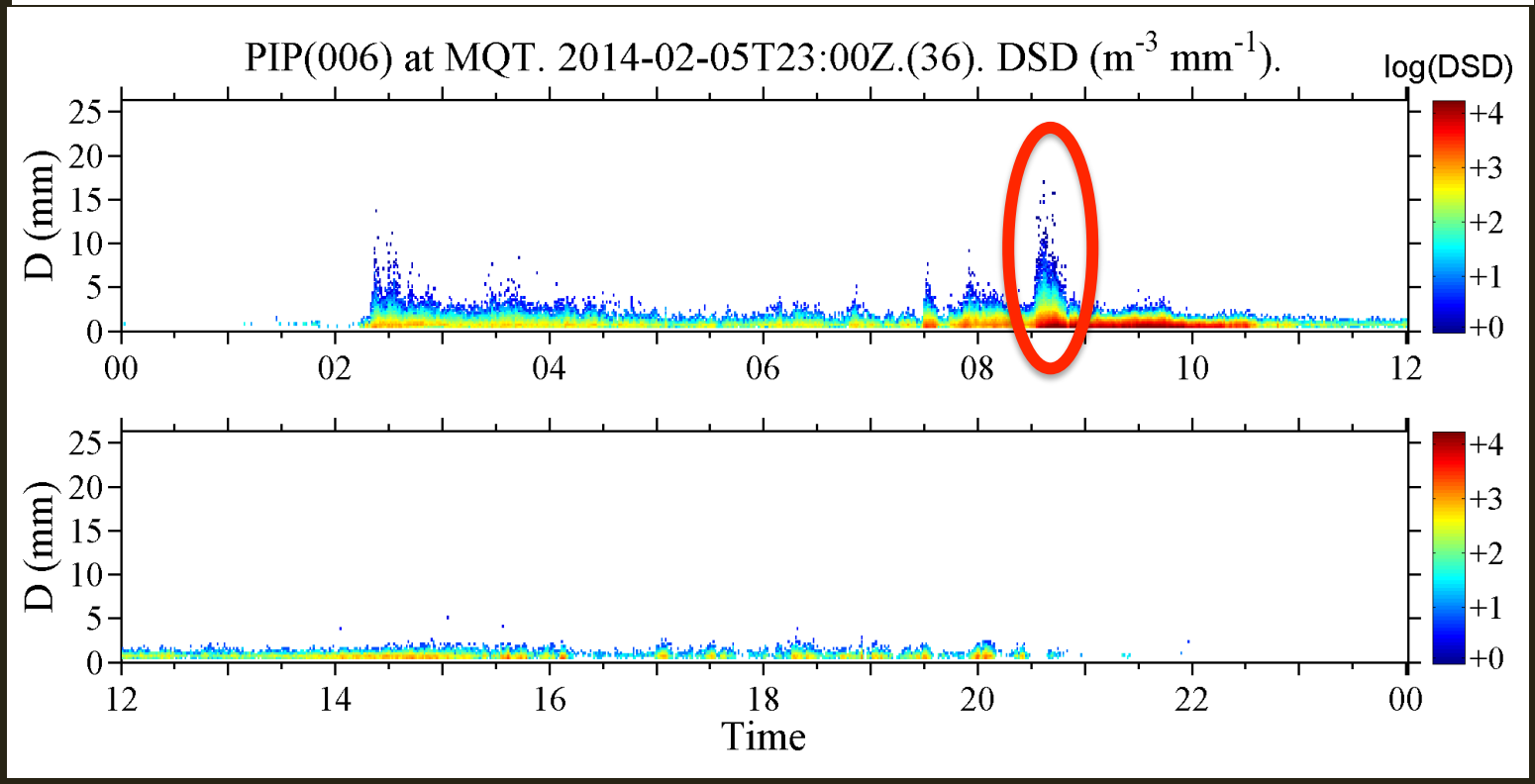

Particle Size Distribution
1.0E+04
1.0E+03
1.0E+02
1.0E+01
1.0E+00
1.0E-01
1.0E-02
N_D [$mm^{-1}m^{-3}$]
1.0
10.0
D_{avg} [mm]
20141110
20141111
20141112

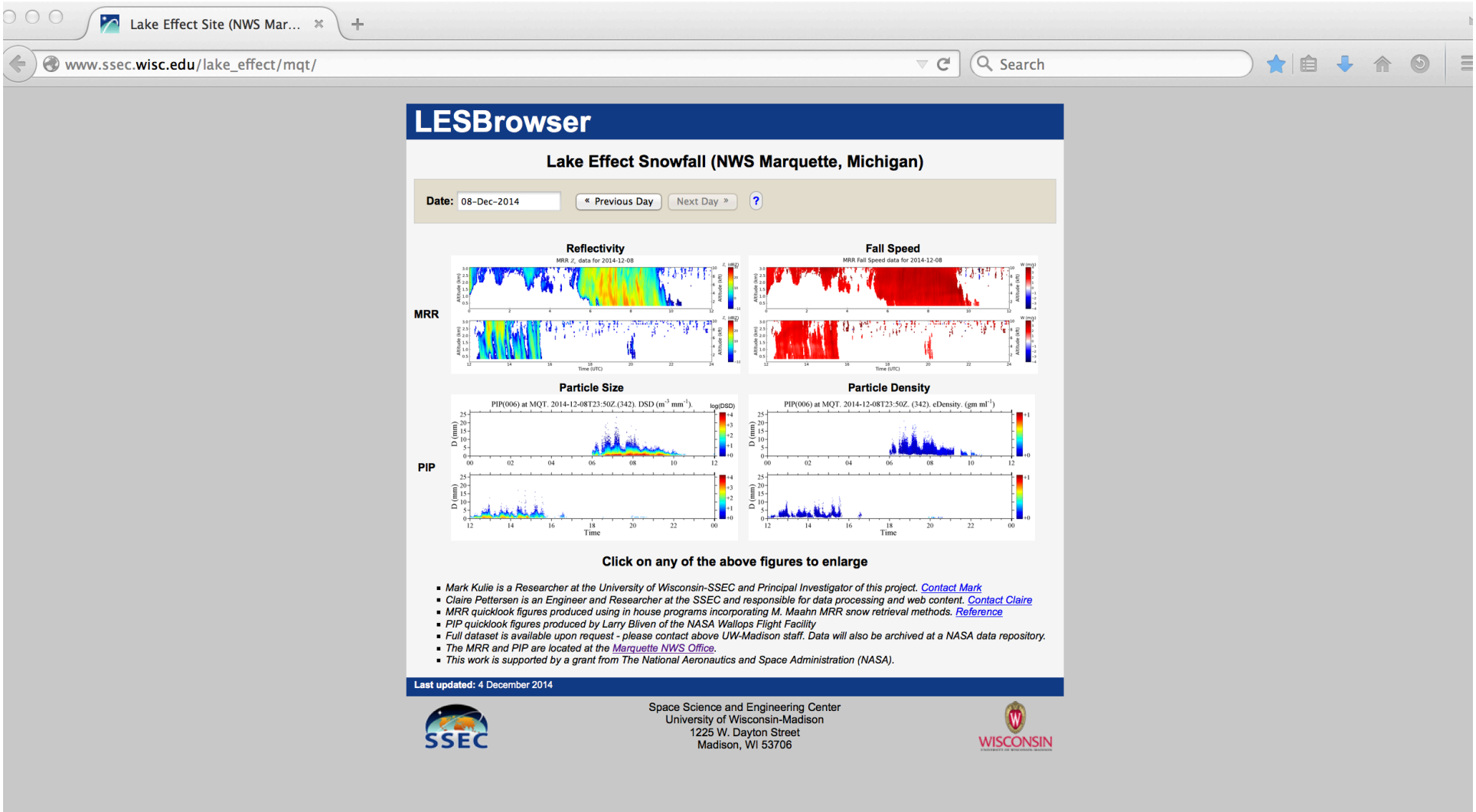

Z-S Relationship
20141110
$Z=55.8S^{0.75}$
20141111
$Z=53.3S^{0.81}$
20141112
$Z=13.6S^{0.87}$
Reflectivity [dBZ]
Not-Rainfall Rate [mm hr^{-1}]


MRR Z_e data for 2014-02-05
Altitude (km)
Altitude (kft)
Z_e (dBZ)
Time (UTC)


PIP(006) at MQT. 2014-02-05T23:00Z.(36). DSD (m^{-3} mm^{-1}).
log(DSD)
D (mm)
Time


MRR Z_e data for 2014-02-05
Altitude (km)
Altitude (kft)
Z_e (dBZ)
Time (UTC)


PIP(006) at MQT. 2014-02-05T23:00Z.(36). DSD (m^{-3} mm^{-1}).
log(DSD)
D (mm)
Time



www.ssec.wisc.edu/lake_effect/mqt

Courtesy of Claire Pettersen

With expert contributions from Aronne Merrelli and Bill Bellon

Postfrontal Convective Snow

- Snowfall mode important
  - Location
  - Radiometric signatures
  - Microphysical composition
  - Environmental conditions
  - GPROF retrieval evaluation

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  - Location
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  - Environmental conditions (GPROF?)
- GPM high freq channels useful
- GV observations
  - Systematic radar/microphysics differences
  - Sub-1km ***extremely*** important
  - Long term observations

Acknowledgments

- NASA PMM: NNX13AG47G
- NASA Wallops Flight Facility
- Marquette, MI NWS WFO