Snow Detection Over Land and Snow Retrieval Database Building Over Ocean

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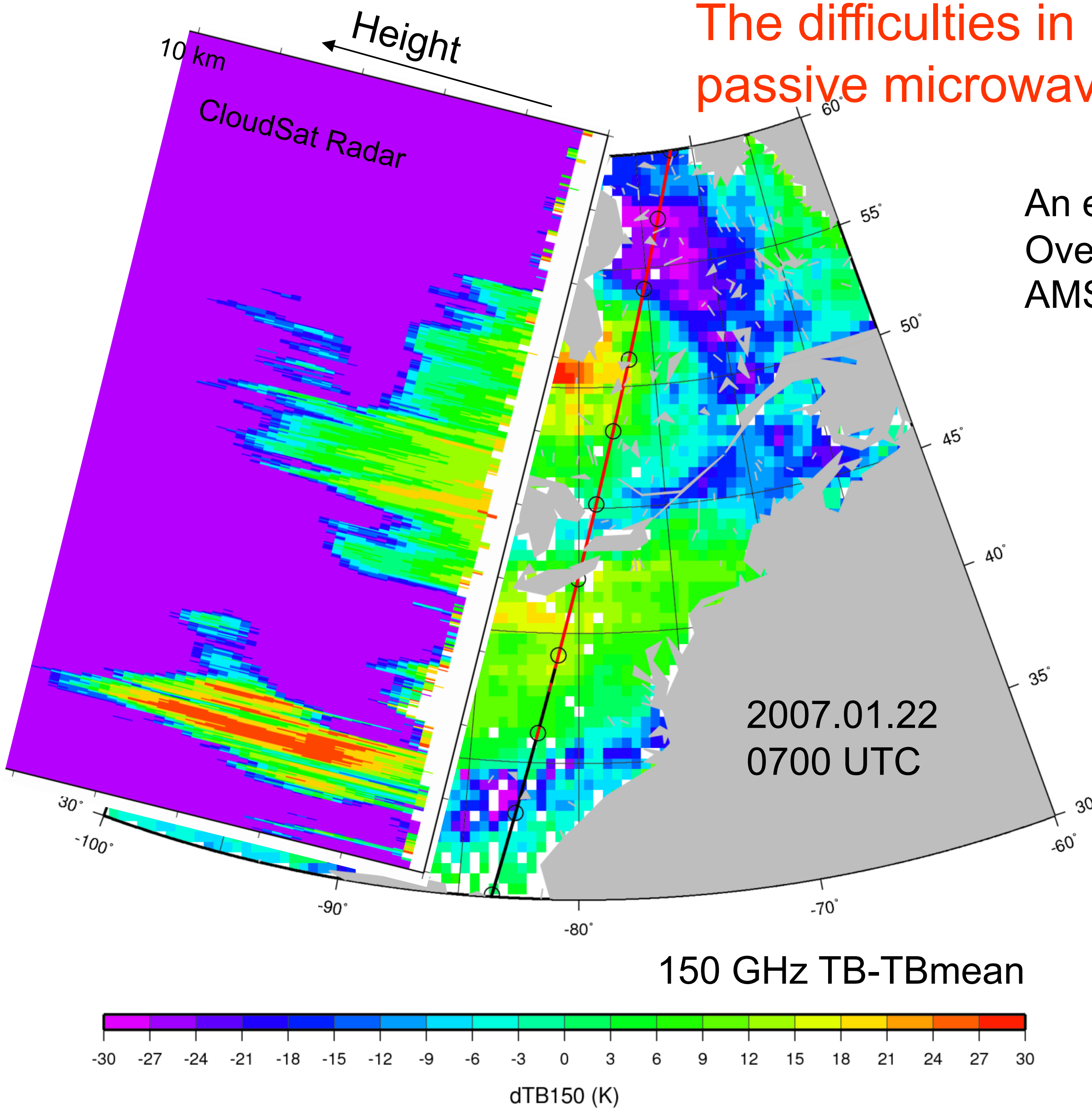
Research During the Past Year

- Scattering Table for Aggregates
- Liquid water characteristics in snowing clouds
- Snow detection algorithm over land
- Snow retrieval database over ocean based on ECMWF

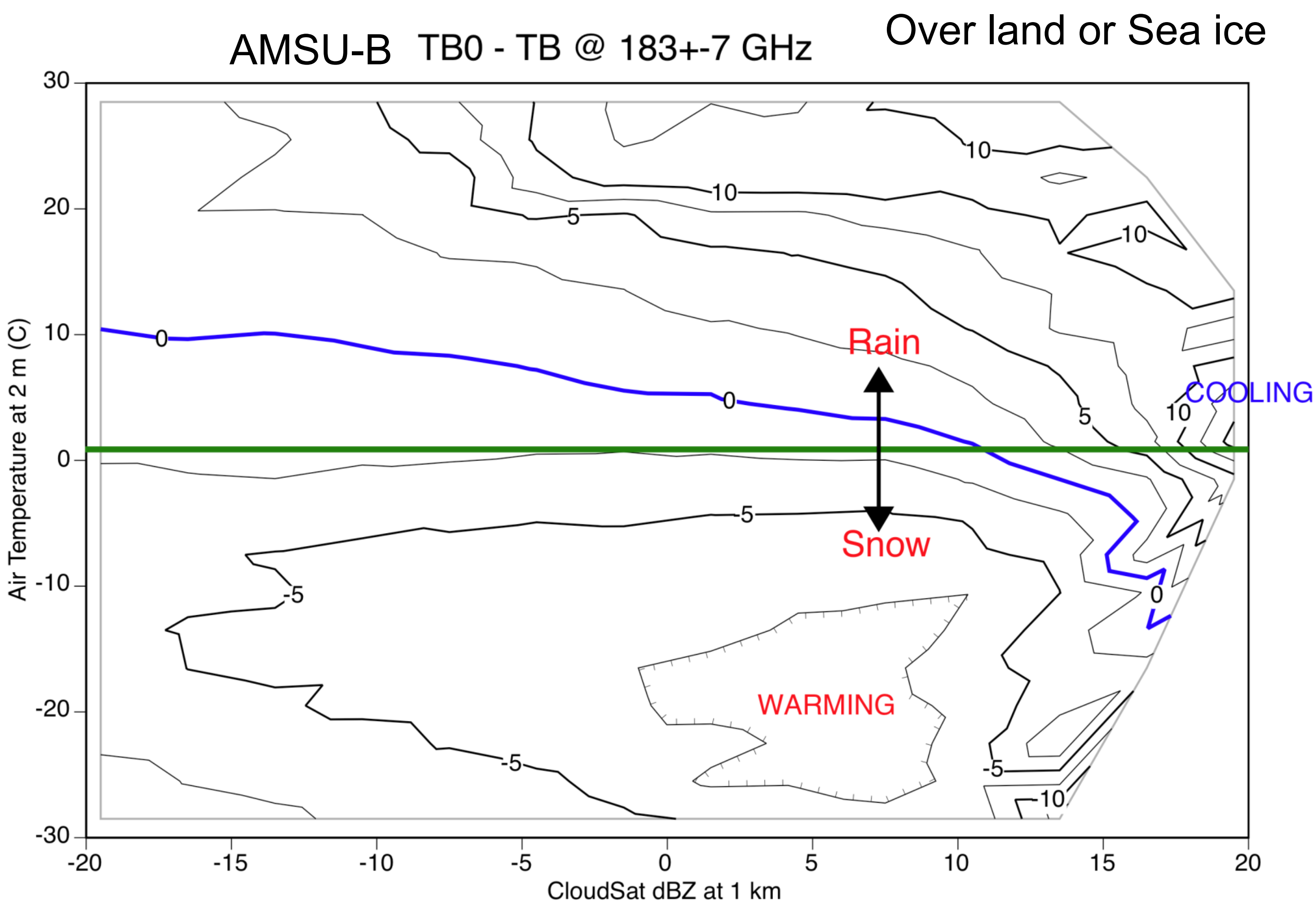
Snowfall Detection Over Land

The difficulties in interpreting passive microwave signatures

An example of snowfall Over land observed by AMSU-B & CloudSat

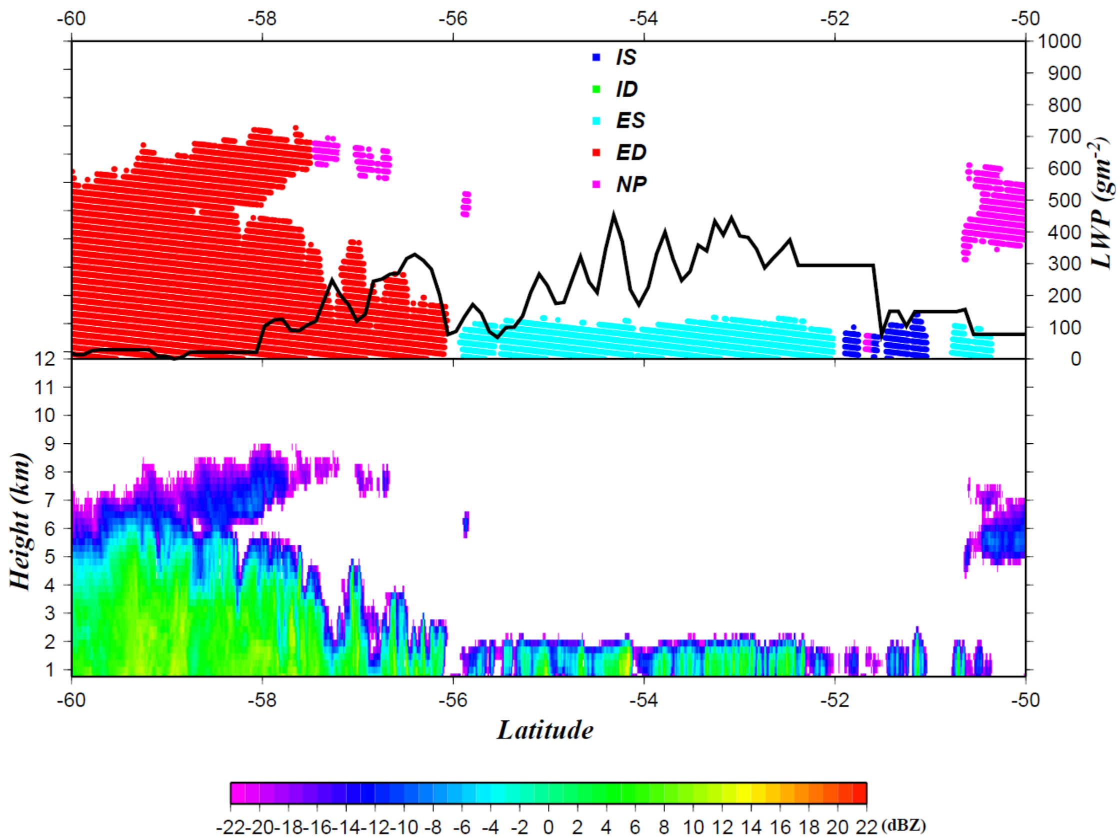


176 GHz TB's Response to Snowfall



Warmer or Cooler at high-frequency microwaves when it is snowing ?

Cloud Liquid Water (07/28/2007)



IS: Isolated Shallow

ID: Isolated Deep

ES: Extended Shallow

ED: Extended Deep

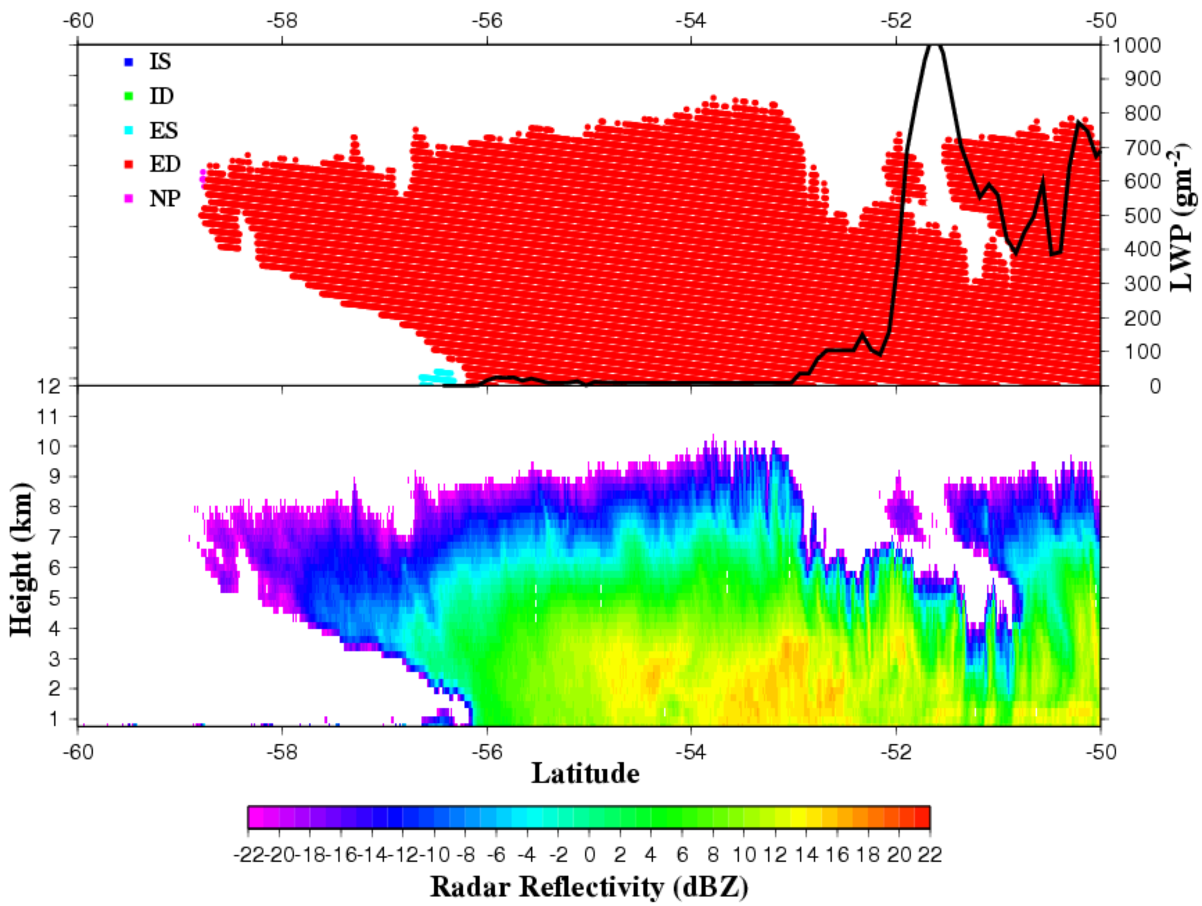
NP: Non-Precip

Shallow < 5km < Deep

Isolated < 40km < Extended

CloudSat dBZ & AMSR-E LWP

Cloud Liquid Water (08/26/2006)



LWP

g m^{-2}

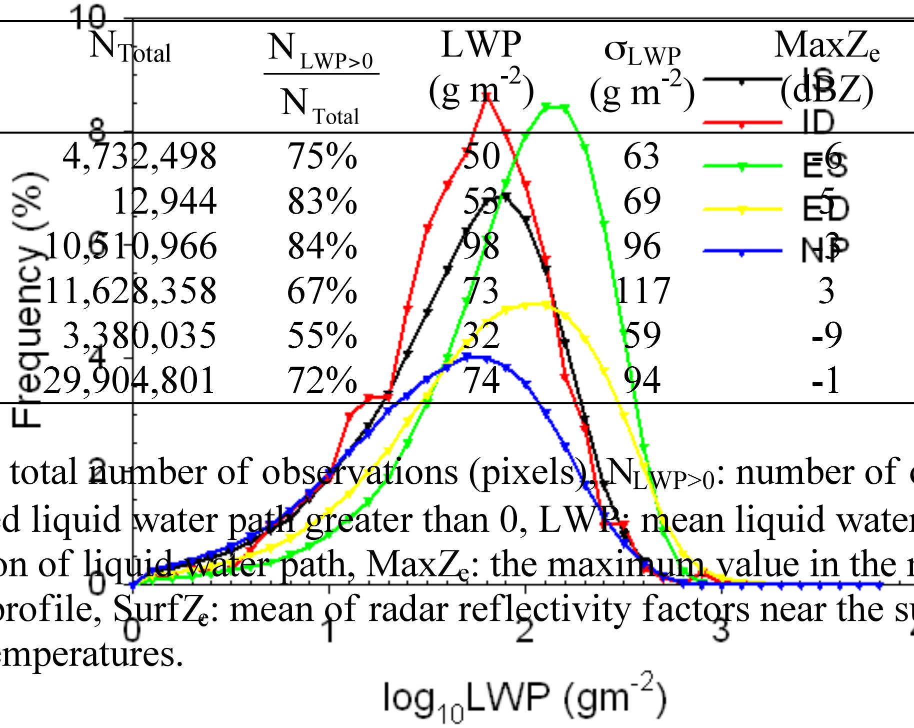
CloudSat dBZ & AMSR-E LWP

The Abundance of Liquid in Snowing Clouds

Table 1. Statistics of Over Ocean Snowing Clouds*

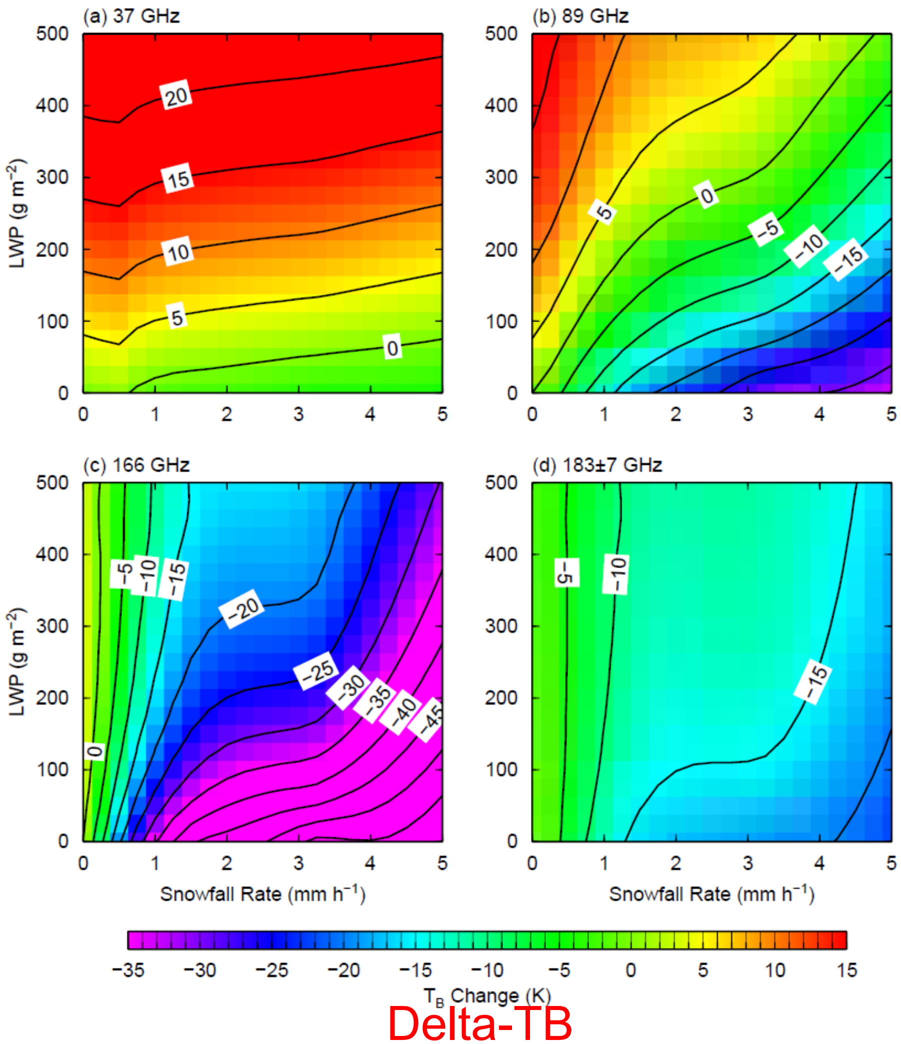
	N_{Total}	$\frac{N_{LWP>0}}{N_{Total}}$	LWP ($g\ m^{-2}$)	σ_{LWP} ($g\ m^{-2}$)	$MaxZ_e$ (dBZ)	$SurfZ_e$ (dBZ)	T_{2m} (°C)
IS	4,732,498	75%	50	63	-6	-8	-9.4
ID	12,944	83%	53	69	5	-2	0.4
ES	10,510,966	84%	98	96	-3	-5	-14.2
ED	11,628,358	67%	73	117	3	0	-13.9
NP	3,380,035	55%	32	59	-9	-	-6.4
ALL	29,904,801	72%	74	94	-1	-4	-13.1

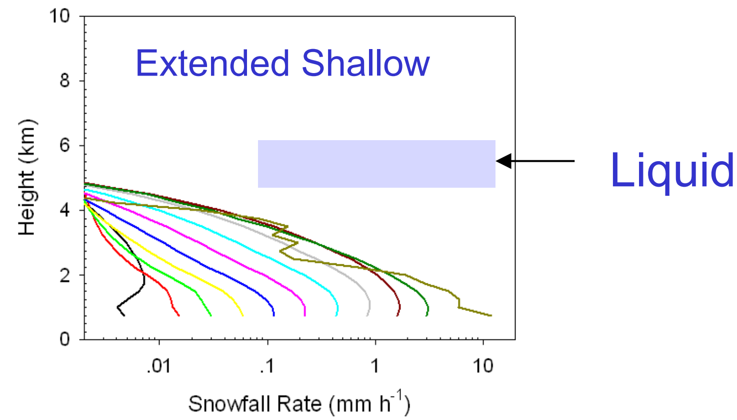
* N_{Total}: total number of observations (pixels), $N_{LWP>0}$: number of observations that have retrieved liquid water path greater than 0, LWP: mean liquid water path, σ_{LWP}: standard deviation of liquid water path, $MaxZ_e$: the maximum value in the mean radar reflectivity factor profile, $SurfZ_e$: mean of radar reflectivity factors near the surface, T_{2m}: mean of 2-m air temperatures.



Impact on Brightness Temperatures – RT Model Runs

(GMI Frequencies, 53 degree Viewing Angle, High-Lat Winter Atmosphere, Ocean)





- 37 GHz: mostly warming, good for liquid water retrieval

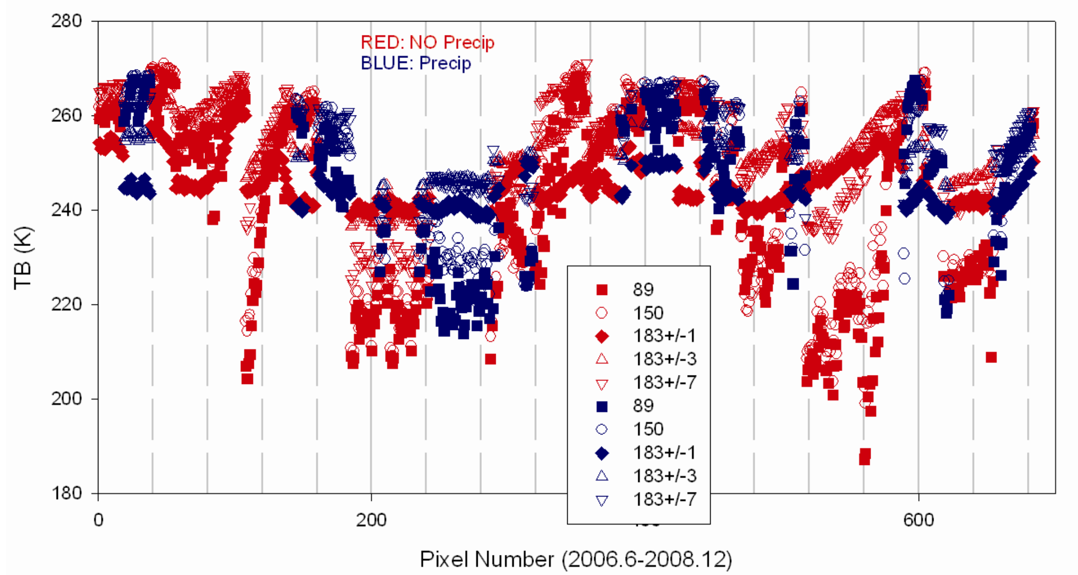
- 89 GHz: competing between liquid-warming and snow-cooling

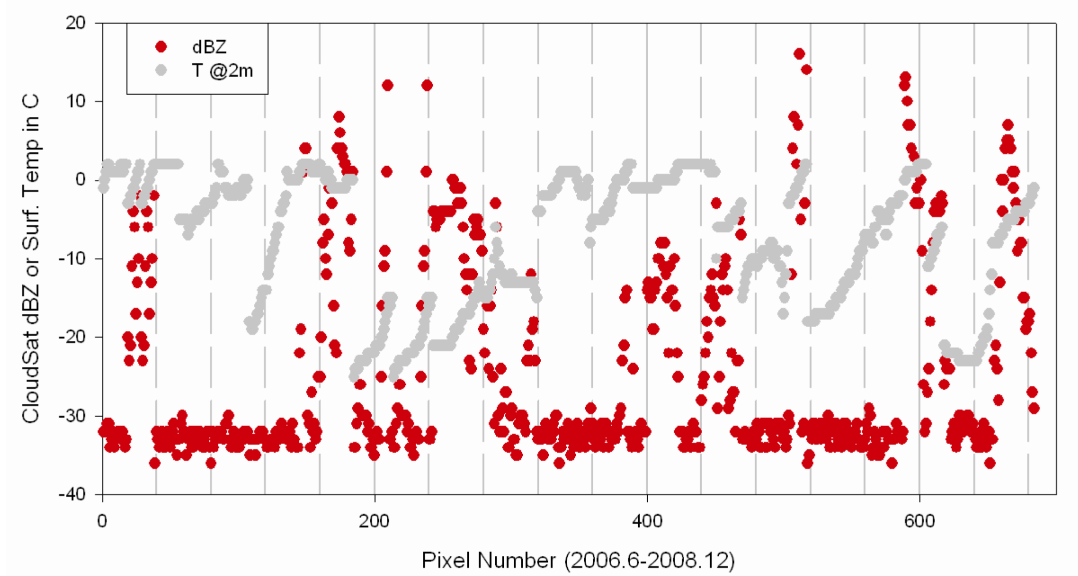
-166 GHz: snowing cooling dominates, but liquid significantly reduces the scattering signature

- 183+/-7 GHz: vapor effect strong. Because viewing at 53 degree, vapor effect much stronger than that so-far-seen at MHS channels

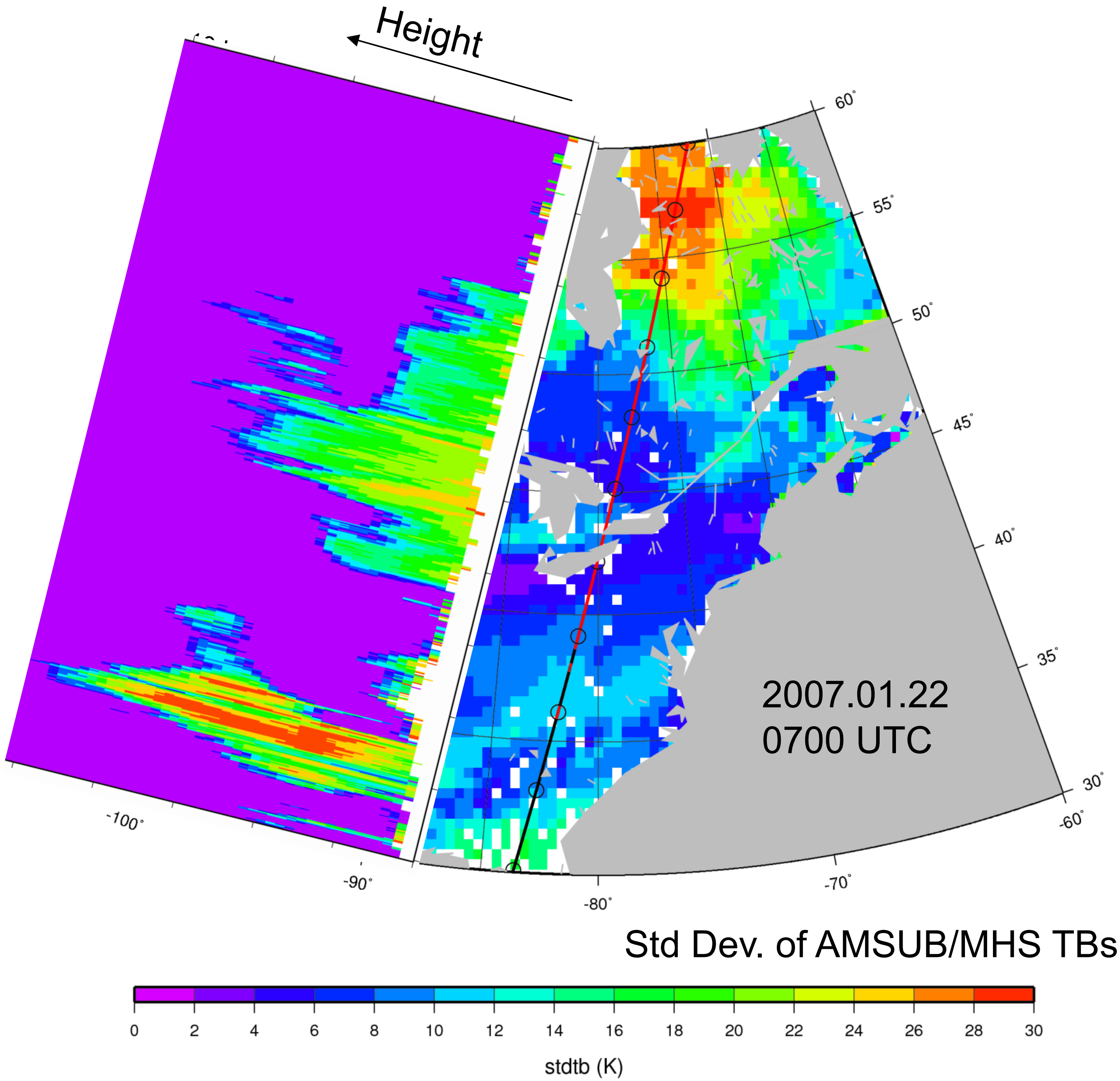
Collocated AMSUB and CloudSat

Surface Air Temp. < 2C
40-50N, 75-85W
2006.06 – 2008.12



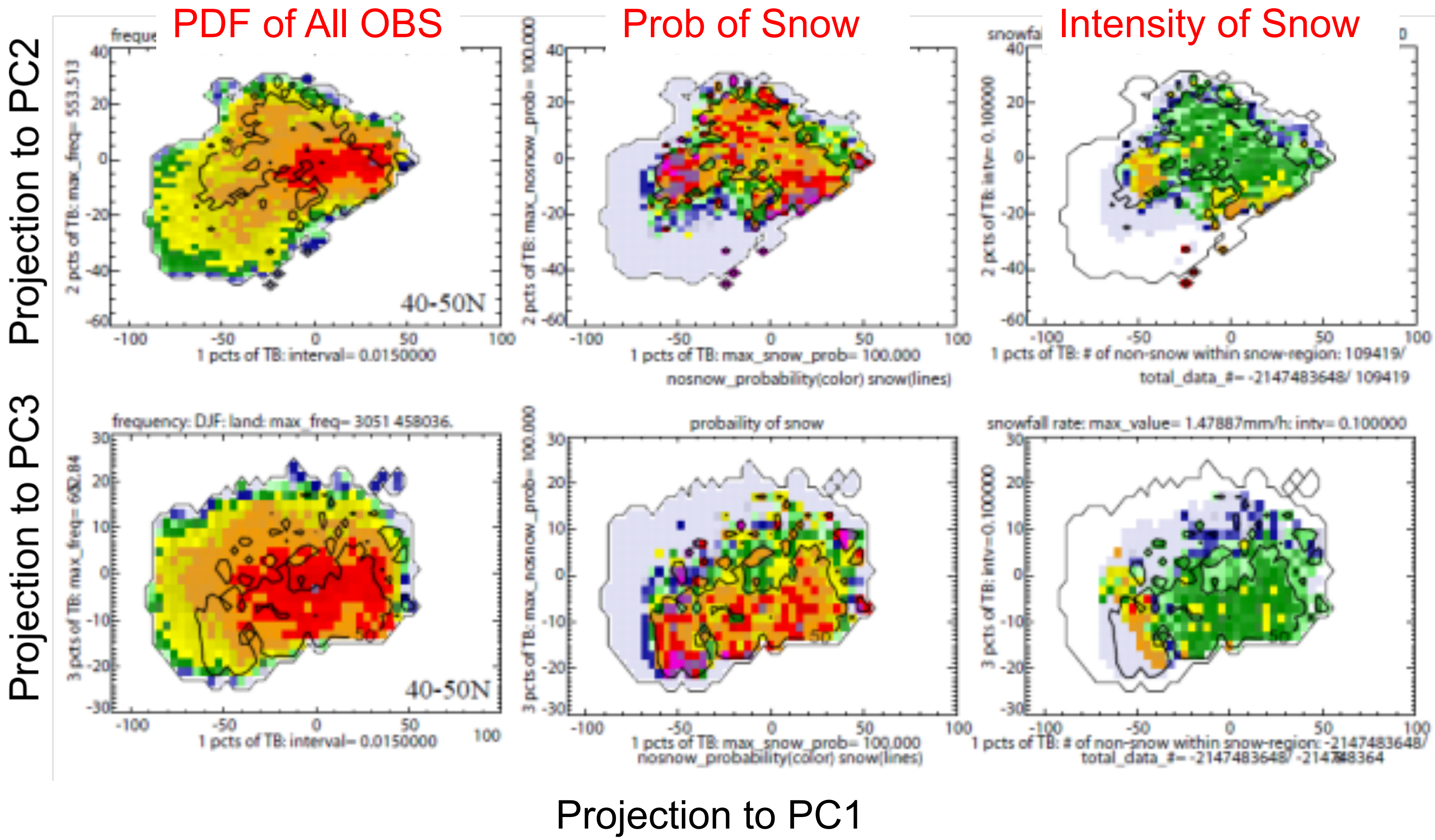


Large TB spread for cold-clear-days

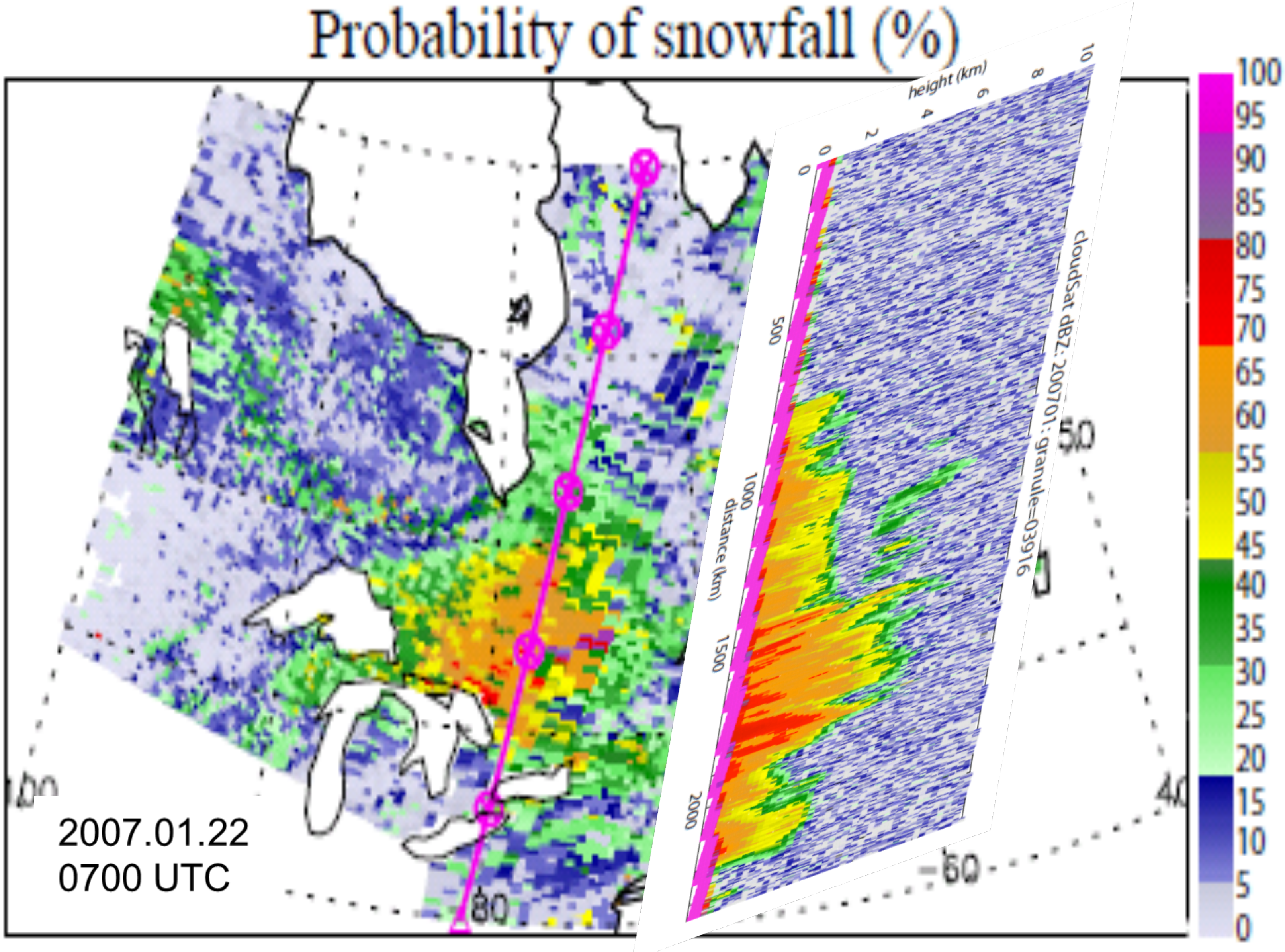

Height
60°
55°
50°
45°
40°
35°
30°
-60°
-70°
-80°
-90°
-100°
2007.01.22
0700 UTC
Std Dev. of AMSUB/MHS TBs
0
2
4
6
8
10
12
14
16
18
20
22
24
26
28
30
stdtb (K)

Snowfall Probability in (AMSU-B) TB's EOF Space

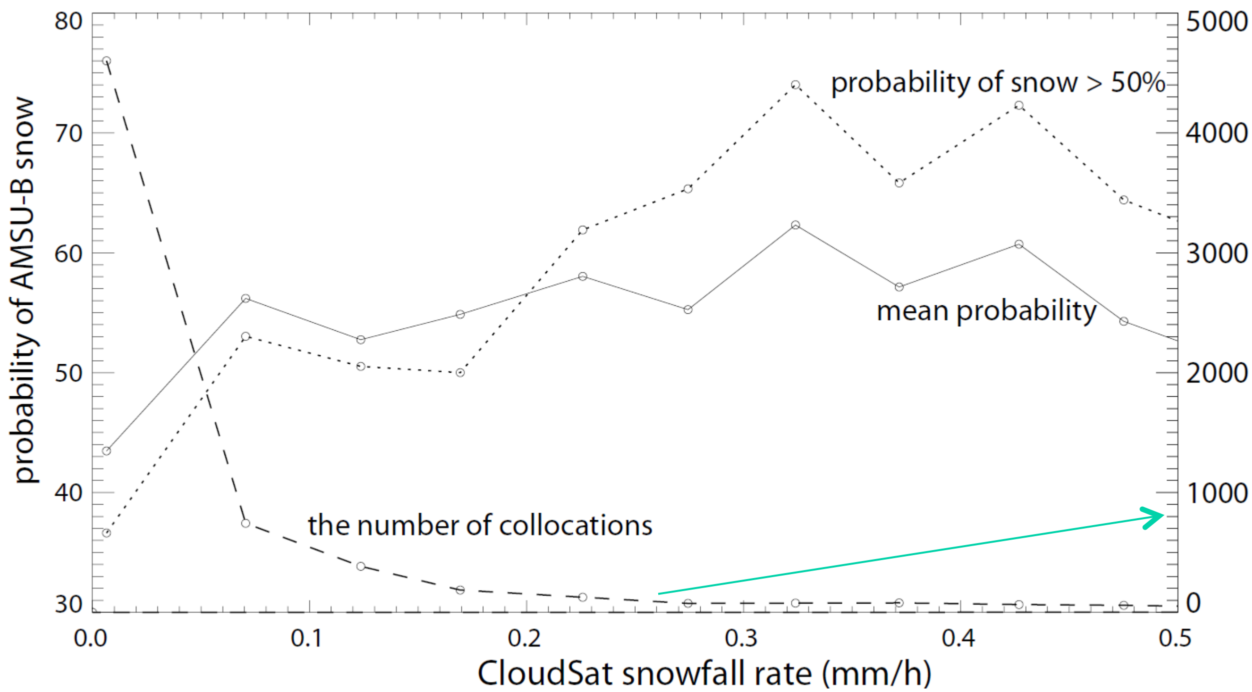
- Collocate AMSU-B/MHS with CloudSat
- EOF Analysis of AMSU-B/MHS TB's, Use First 3 PCs
- Determine Snowfall Probability in EOF Space



The C3VP Example



Preliminary Statistics for Snow Cases During 3 Winters in the Region 40-60N, 50-100W



		CPR	
		Yes	No
AMSU-B	Yes	Hits 37.3%	False Alarms 38.7%
	No	Misses 5.3%	Correct Negatives 18.8%

Building Retrieval Database Over Ocean Based on ECMWF & RTM

Data

2005.11.01 – 2006.6.30

ECMWF (provided by Greg Elsaesser, CSU)

Original resolution:

- T799: ~25km (?)
- 4 forecasts/day

Thinned Data

- Sample every 5th latitude and every 5th longitude
- Sample every 10th day

Variables

- Cloud liquid, cloud ice, rain, snow, cloud fraction, T, Ts, T2m, q, p, …

SSMIS (L1C from CSU)

- 92V, 92H 150H, 183+/-1H, 183+/-3H, 183+/-7H
- 14x13, 14x13, 14x13, 14x13, 14kmx13km

Radiative Transfer Model (Liu, 1998)

Gas absorption: Rosenkranz (1998)

Sea Surface Emissivity: Guillou et al. (1998) ocean + Schluessel and Luthardt (1996) wind adjustment

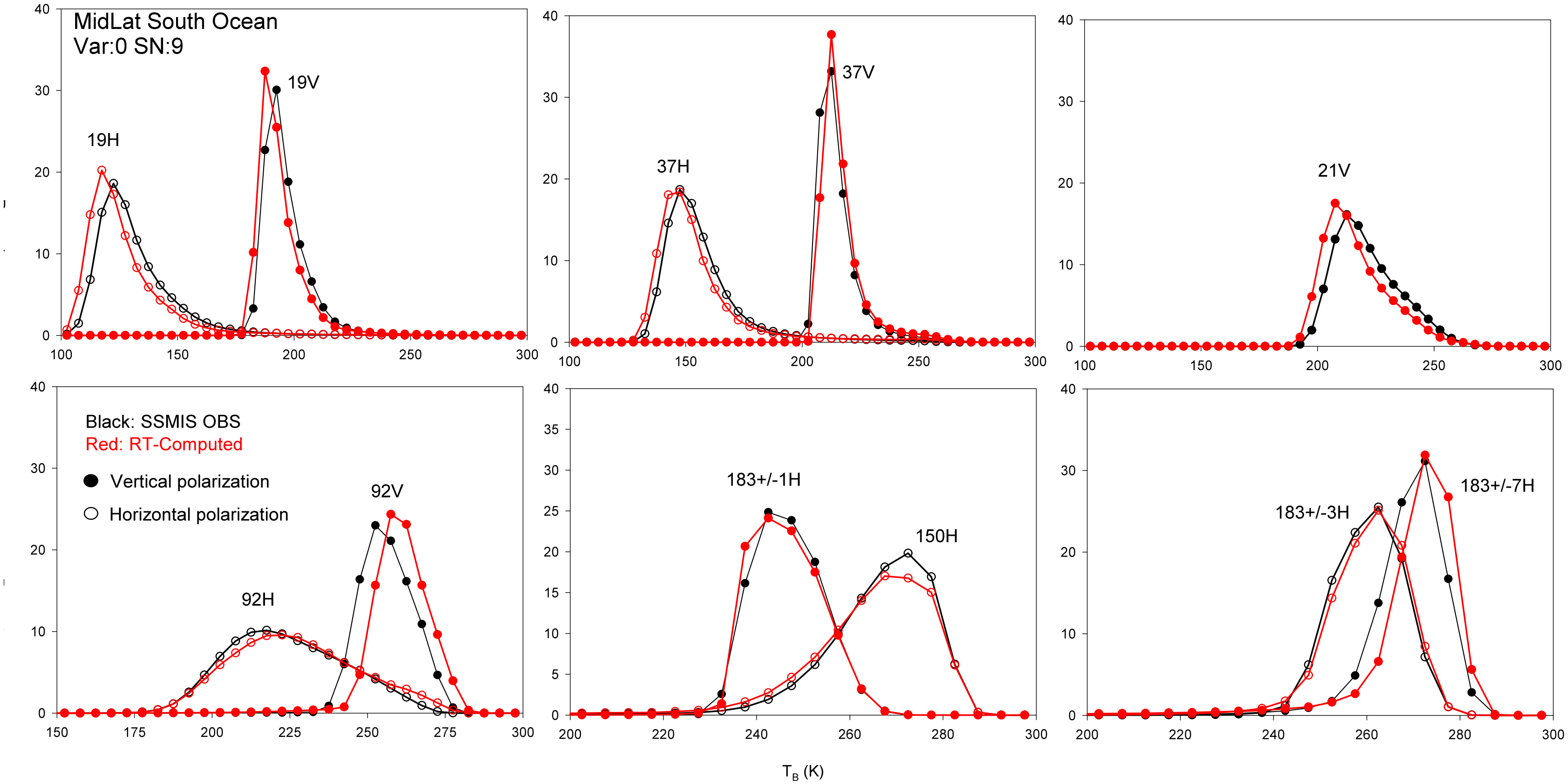
Fresnel reflection

Delta-4 Stream

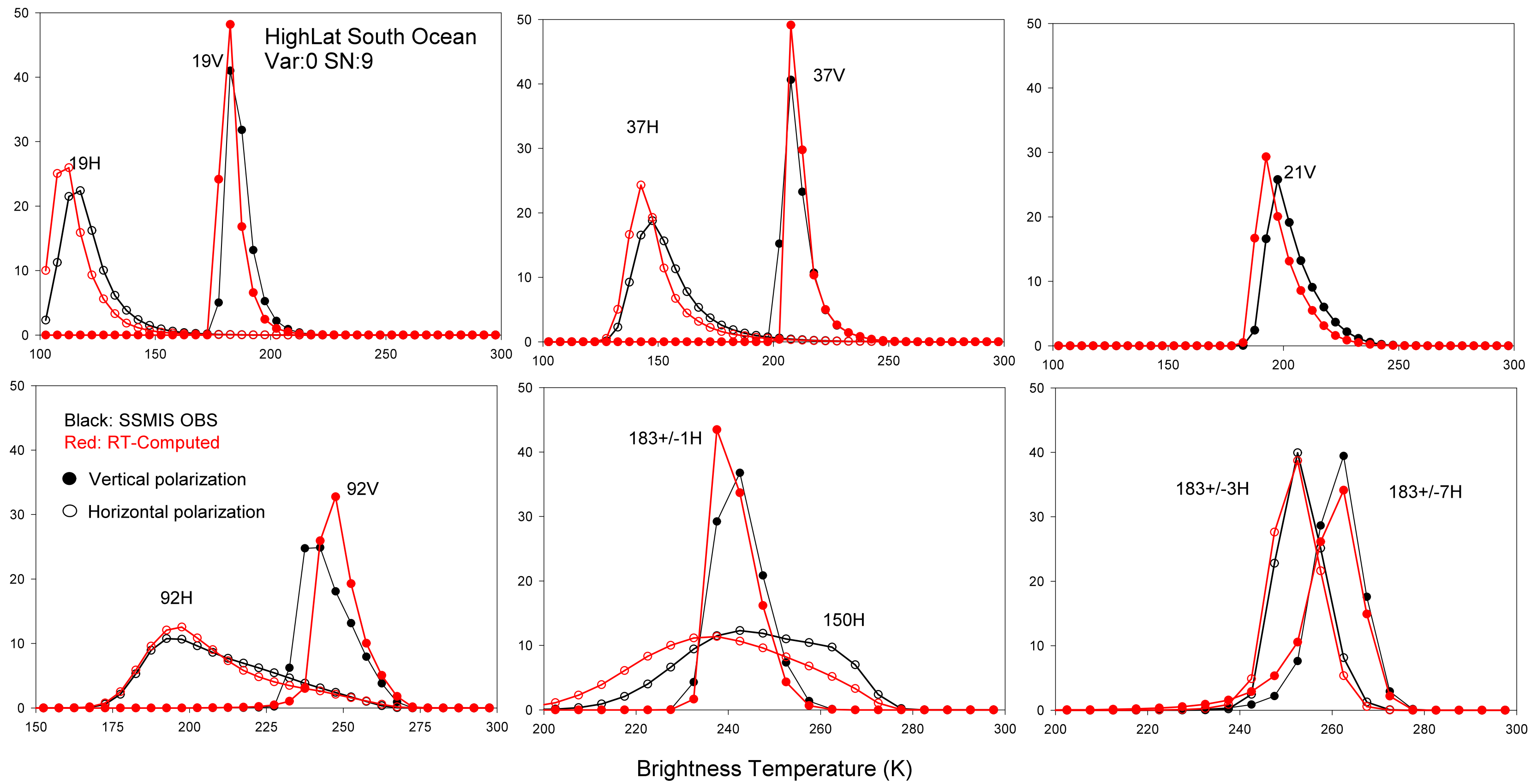
Water Species: cloud water, cloud ice, rain, snow, graupel (did not use in this study)

Ice/snow shapes: rosettes, sectors, dendrites (scattering properties from DDA)

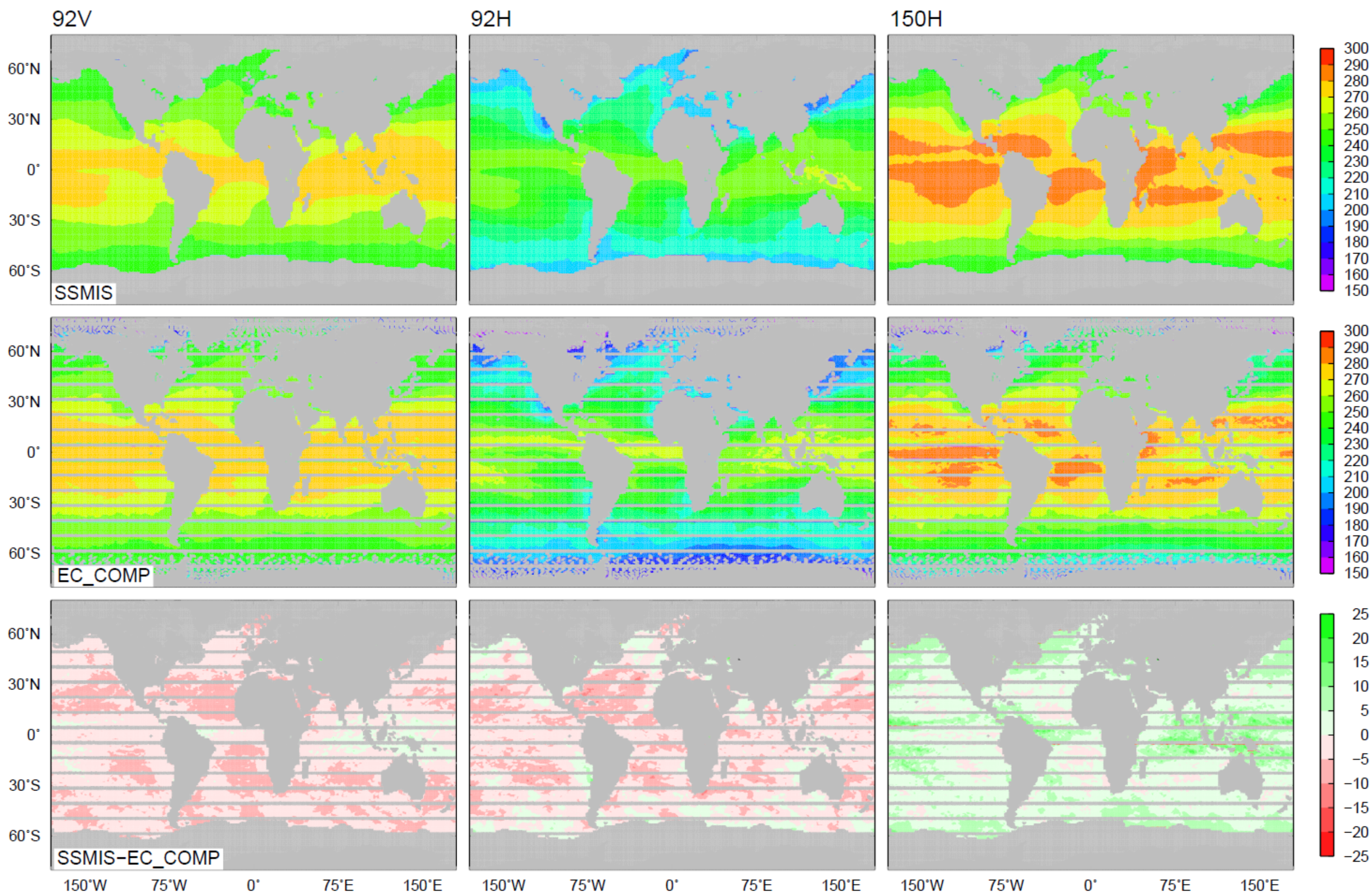
Histogram MidLat (30S-40S)



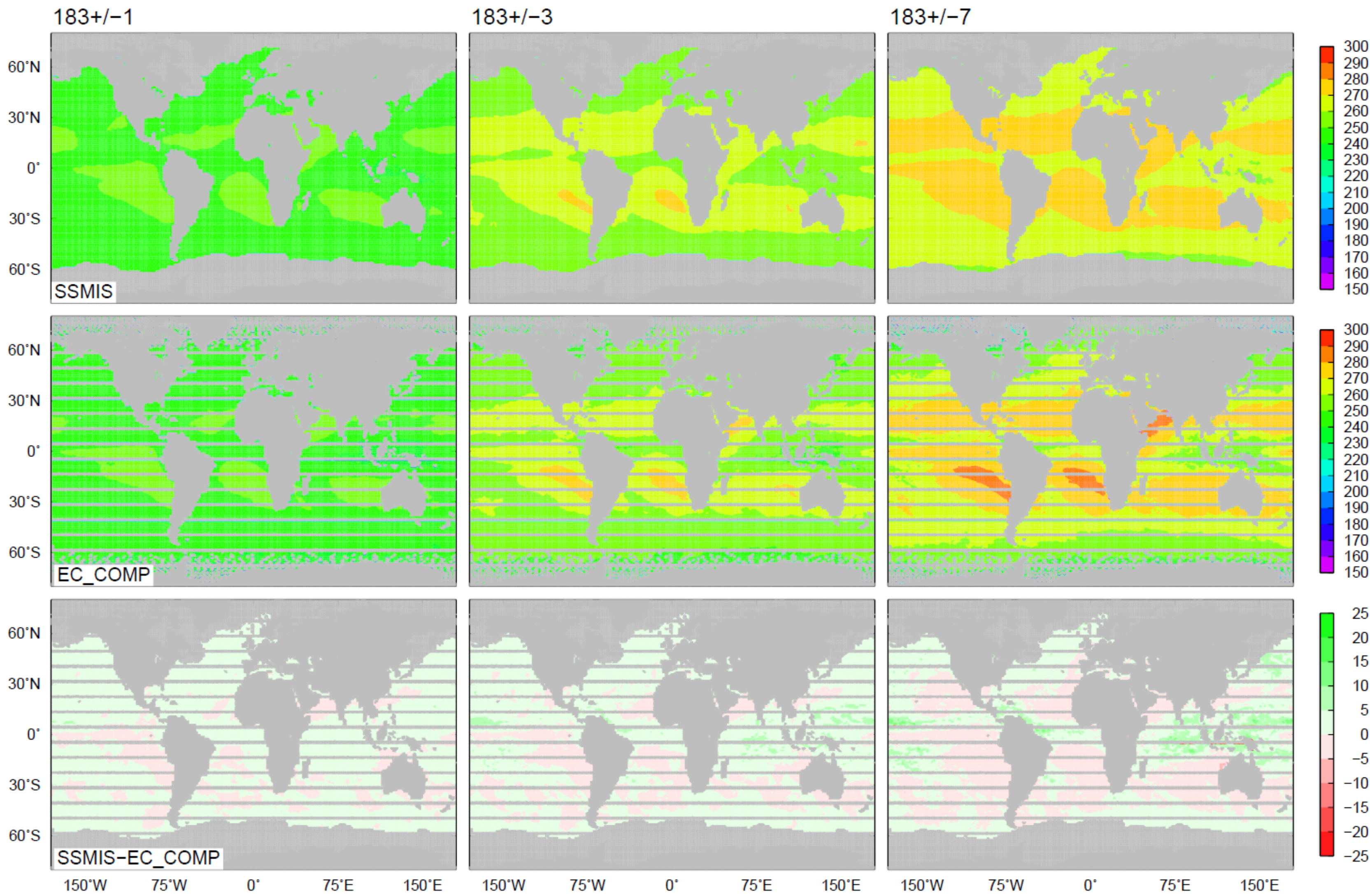
Histogram HighLat (50S-60S)



Mean TBs (92 & 150 GHz)

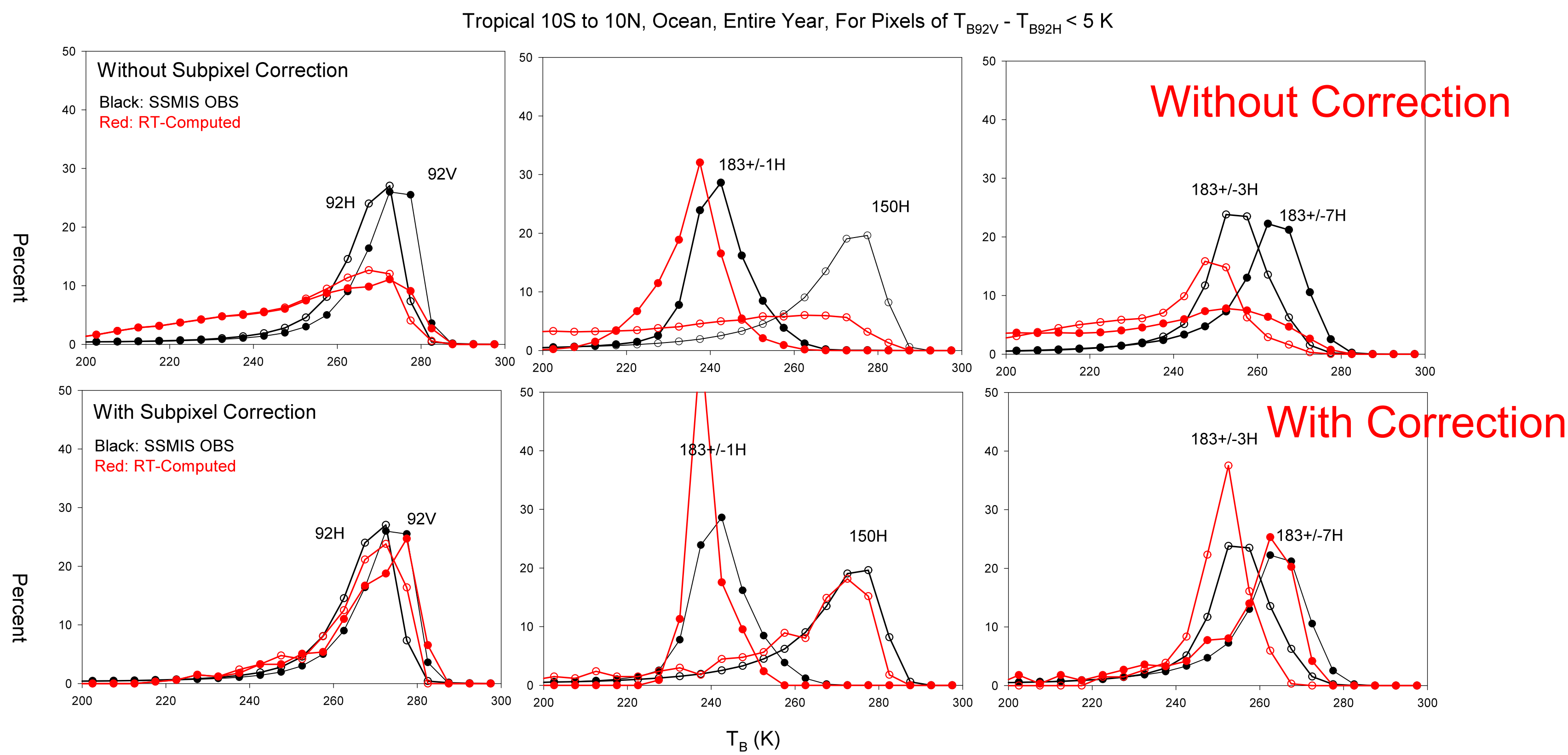


Mean TBs (183+/-1,3,7 GHz)

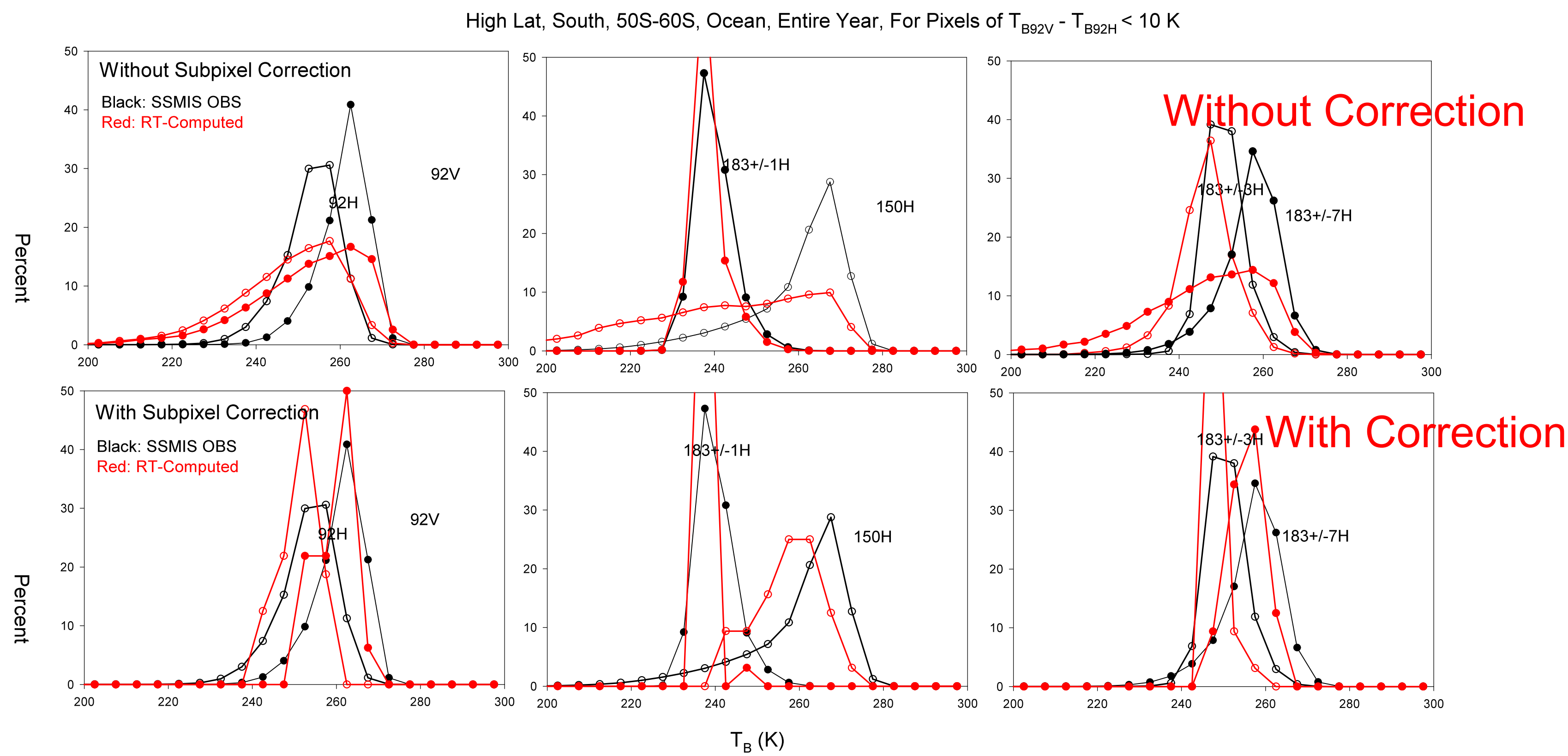


For Raining/Snowing pixels Only

- The importance of using sub-pixel variability correction



Same Effect, But May Be Less Significant for Higher Latitudes (lower rainrates)



Conclusions

- Snowfall Detection Over Land:
  - Liquid Water in Snowing Cloud – A big problem, in addition to surface emissivity uncertainty
  - EOF-based detection method shows promising results
- Snowfall Retrieval Over Ocean:
  - Database Building: ECMWF + RT shows similar TB histogram to SSMIS's
  - However, for precipitating conditions, sub-pixel variability correction needed.
- See Poster for Details