Winter Precipitation Type From Microwave Radiometer in New York State Mesonet Profiler Network

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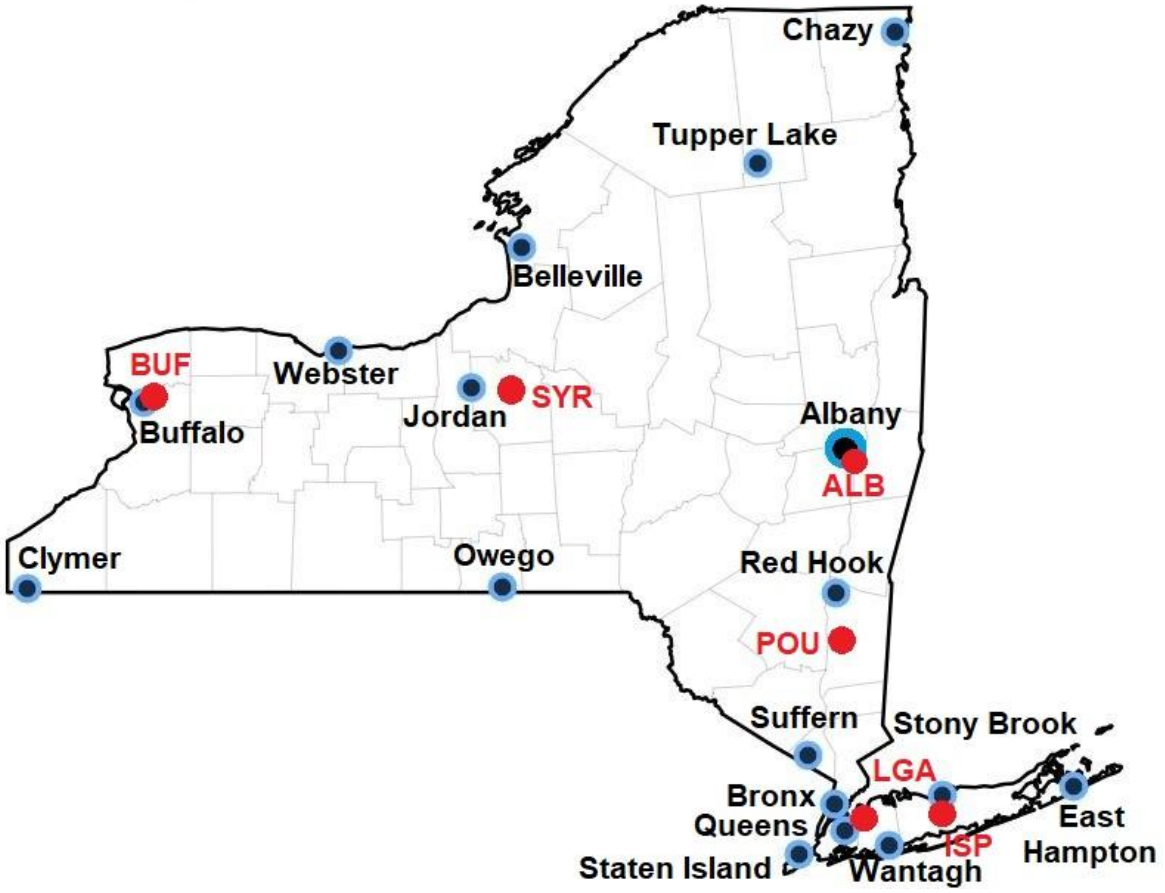
Background and Motivation

- Winter precipitation presents an adverse impact on human health and safety and economy, particularly due to snow, freezing rain and sleet
- Accurate determination of precipitation type (p-type) has been a long ongoing challenge for forecasters
  - Models have higher uncertainties in forecasting freezing rain and sleet
  - Insufficient understanding of microphysical processes and lack of adequate observational p-type data
- The profiles of temperature and moisture are critical observations:
  - Determine the p-type observed at the surface
  - Help to understand thermodynamic changes taking place aloft
- Microwave Radiometer (MWR) provides thermodynamic profiles from the surface to 10 km every ~2min

NYSM Profiler Network

- The New York State Mesonet (NYSM) Profiler Network operates 17 profiler sites across the New York state
  - Each site has collocated Leosphere/Vaisala Doppler lidar and Radiometrics MWR
- The NYSM Profiler Network provides wind & aerosol profiles up to 7 km and thermodynamic profiles up to 10 km every 1-2 minutes
- All the data are collected, quality-controlled, and archived in real-time every 10 minutes
- Real-time profiler data display available at: http://www.nysmesonet.org/networks/profiler

NYSM Profiler Network



A map of NYSM Profiler Network along with six selected ASOS sites (red dots)

NYSM Profiler Network site at Queens

Methodology

- Application of Par d,1993) to MWR data:
  - 1000-700 hPa as H
  - 850-700 hPa (H1)
- Threshold criteria a tory analysis
  - H2 increased by 1
  - H1 > 1570 m adde

Thickness (m)		P-type
850 – 700 hPa (H1)	**1000 – 850 hPa (H2)**	
< 1540	< 1300	SN
	1300 - 1320	SLT/SN
	> 1320	RA
≥ 1540	< 1300	SN if H1 ≤ 1545
		SLT/SN if H1 > 1545
	1300 - 1320	FZR/RA
	> 1320	RA
1570 - 1595	> 1295	FZR/RA
1595 - 1605		FZR/SLT
≥ 1605	≥ 1310	FZR
	< 1310	SLT

Additional conditions:

- *If P-type = SN and Ts > 0 °C → RA/SN*
- *If H2 > 1335 and Ts > -1 °C → RA*
- *If MWR T profile ≤ -3 °C → SN*
- *If Ts > 7 °C → RA*
- *If all T's > 0 °C and Tmax > 2 °C within first 50 hPa → RA*

Methodology

- MWR 10 min p-types are derived from 2020 to 2022 (Nov – Apr) at Queens, Stony Brook, Red Hook, Albany, Jordan and Buffalo compared against:
  - mPING observations (reports from citizen scientists) within 15 km radius
  - ASOS observations in vicinity
- A match is considered when MWR p-type agrees with or is in a mix with mPING or ASOS
- Mixed p-types are collapsed into 4 major p-types with priority order:

FZR > SN > RA > SLT

Methodology

- MWR performance based on confusion matrix and 4 measures:

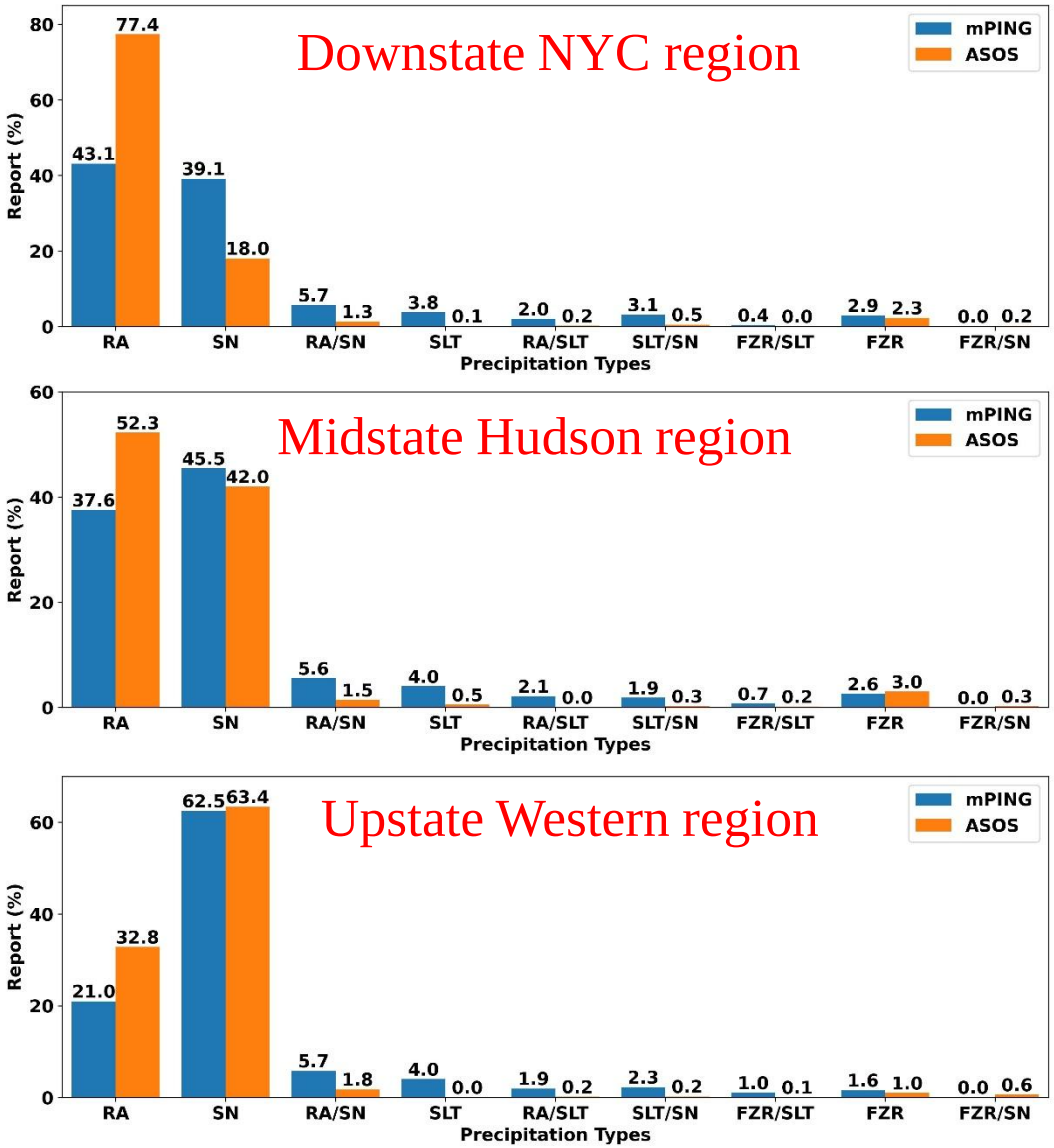
		Observation	
		Y	**N**
Forecast	**Y**	TP (a)	FP (b)
	N	FN (c)	TN (d)

Hit (a)
False alarm (b)
Miss (c)
Correct rejection (d)

  - Probability of Detection (POD) = a/(a+c)
  - Precision = a/(a+b)
  - **Bias (B) = (a+b)/(a+c), B < 1 (under), B = 1 (unbiased) and B > 1 (over)**
  - **Pierce's Skill Score (PSS) = a/(a+c) – b/(b+d)**

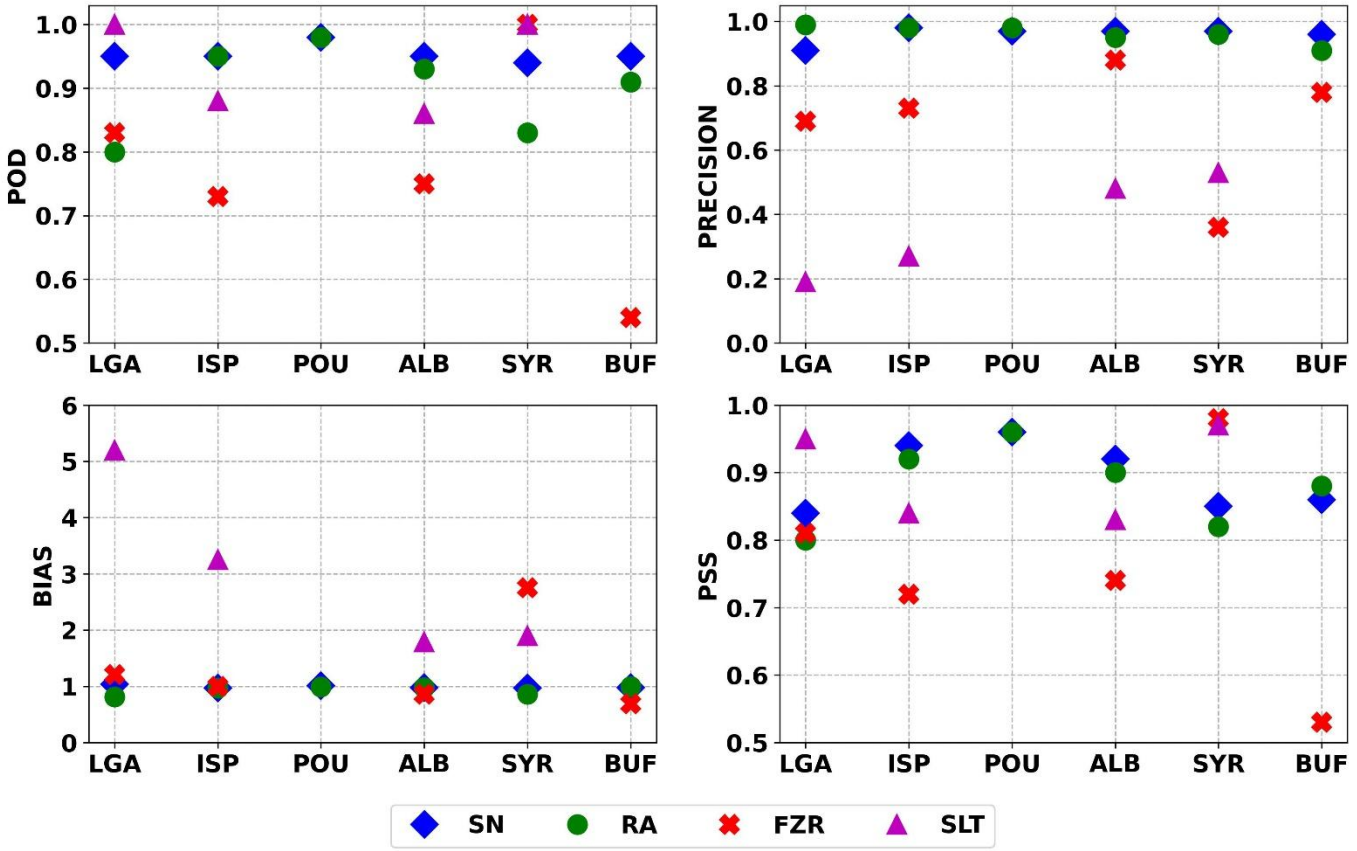
Results: mPING vs ASOS

- mPING users are less inclined to report RA than SN
- mPING (ASOS) comprises 10-12% (2-4%) other p-types than RA, SN or RA/SN
- mPING reports of FZR or its mix are comparable to ASOS (3% vs 2.6%)
- mPING reports of SLT or its mix are much higher than ASOS (9% vs 0.7%)
  - About 66% of mPING SLT reports were either wet SN or FZR (Reeves, 2016)
  - ASOS does not detect SLT (done manually)



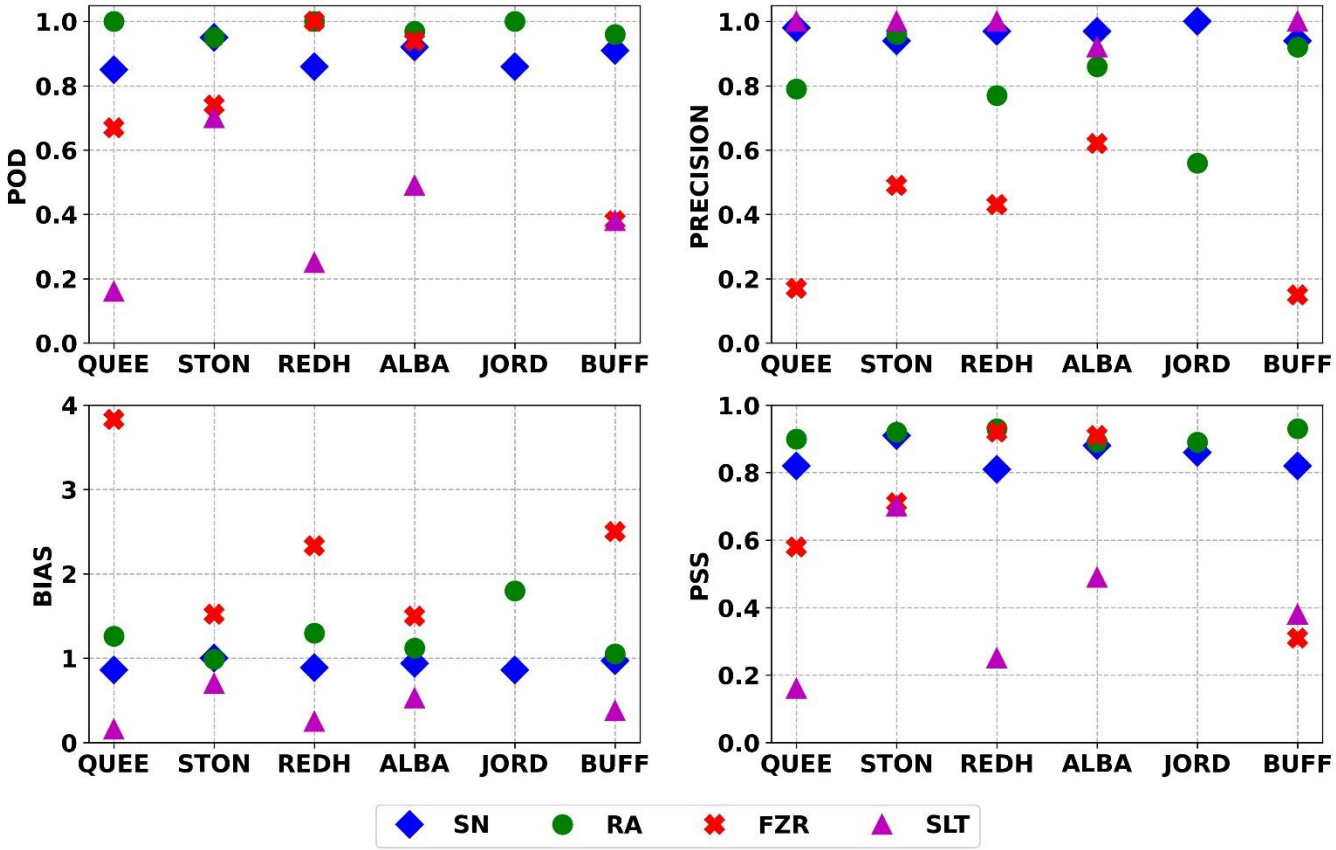
Results: mPING vs ASOS

- POD for SN, RA and SLT ≥ 0.80, mostly lower for FZR (high misses)
- Precisions for SLT are mostly lower (≤ 0.53) – high false alarms
- Significant over-forecasts of SLT, (bias = 1.8 – 5.2)
- PSS > 0.70 mostly but are comparatively lower for FZR as POD



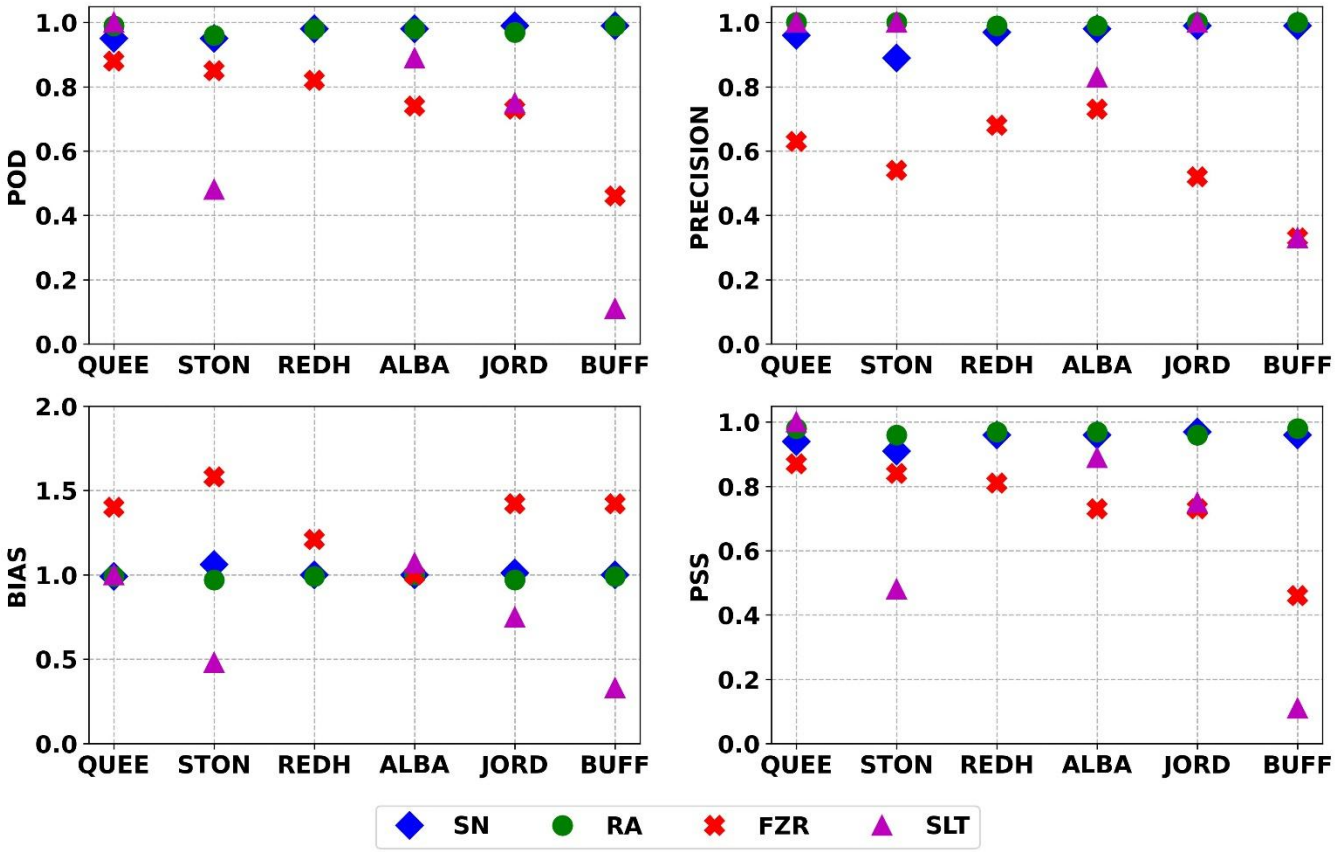
Results: MWR vs. mPING

- POD for SLT lowest, mostly < 0.5 (high misses)
- Precision for FZR lowest, ≤ 0.62 (high false alarms)
- Over-forecasts FZR (>1.5) and under-forecasts SLT (< 0.70)
- PSS similar POD, lowest for SLT



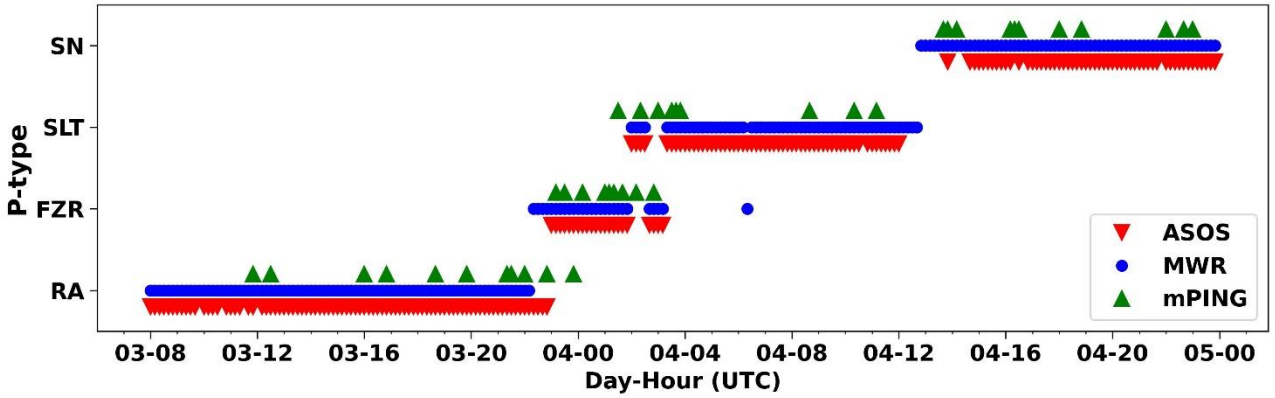
Results: MWR vs. ASOS

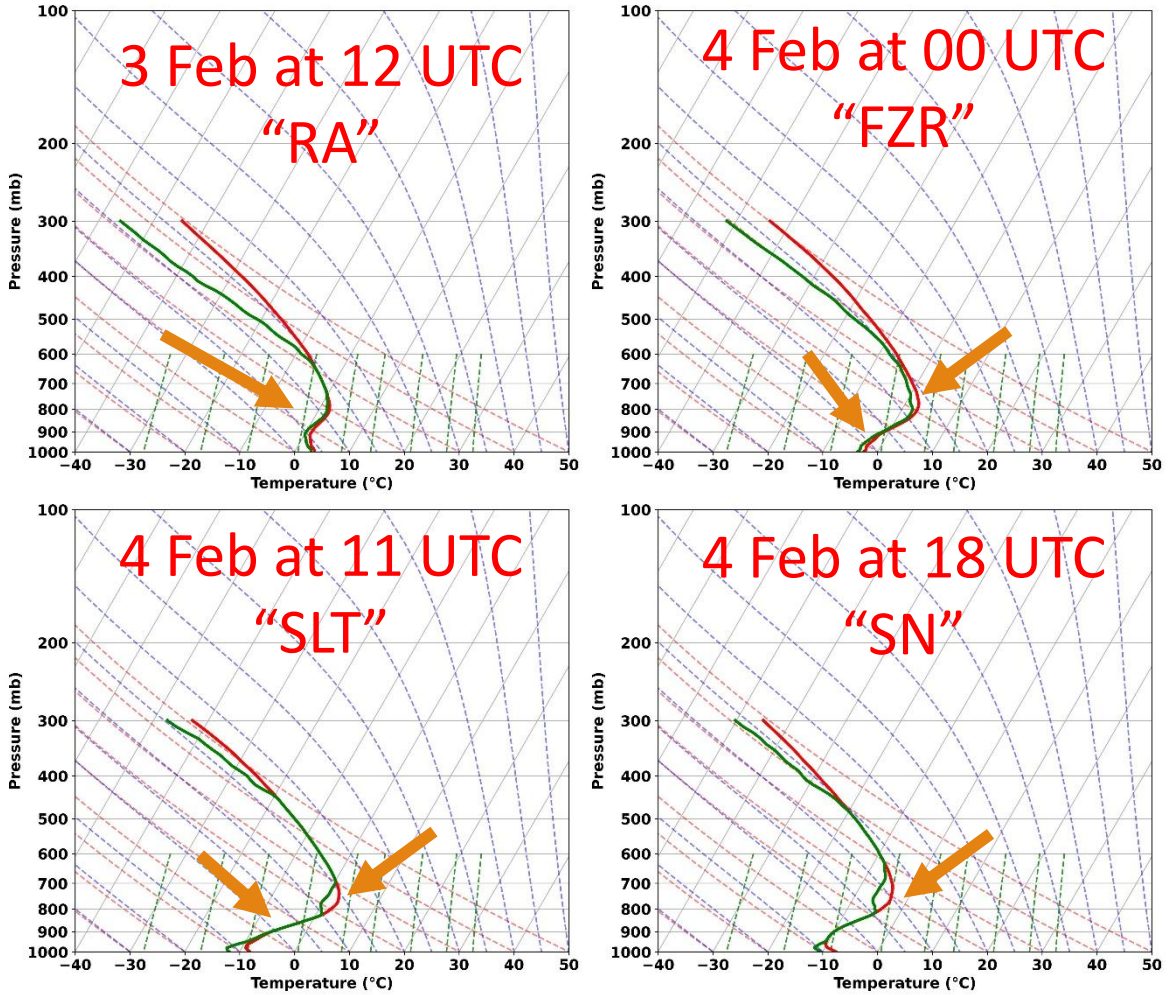
- POD for FZR decreases from QUEE to BUFF, for SLT lowest at STON and BUFF (high misses)
- Precision for FZR lowest (≤ 0.73, high false alarms)
- Over-forecasts FZR (≤1.58) and under-forecasts SLT (STON, JORD, BUFF)
- PSS similar to POD



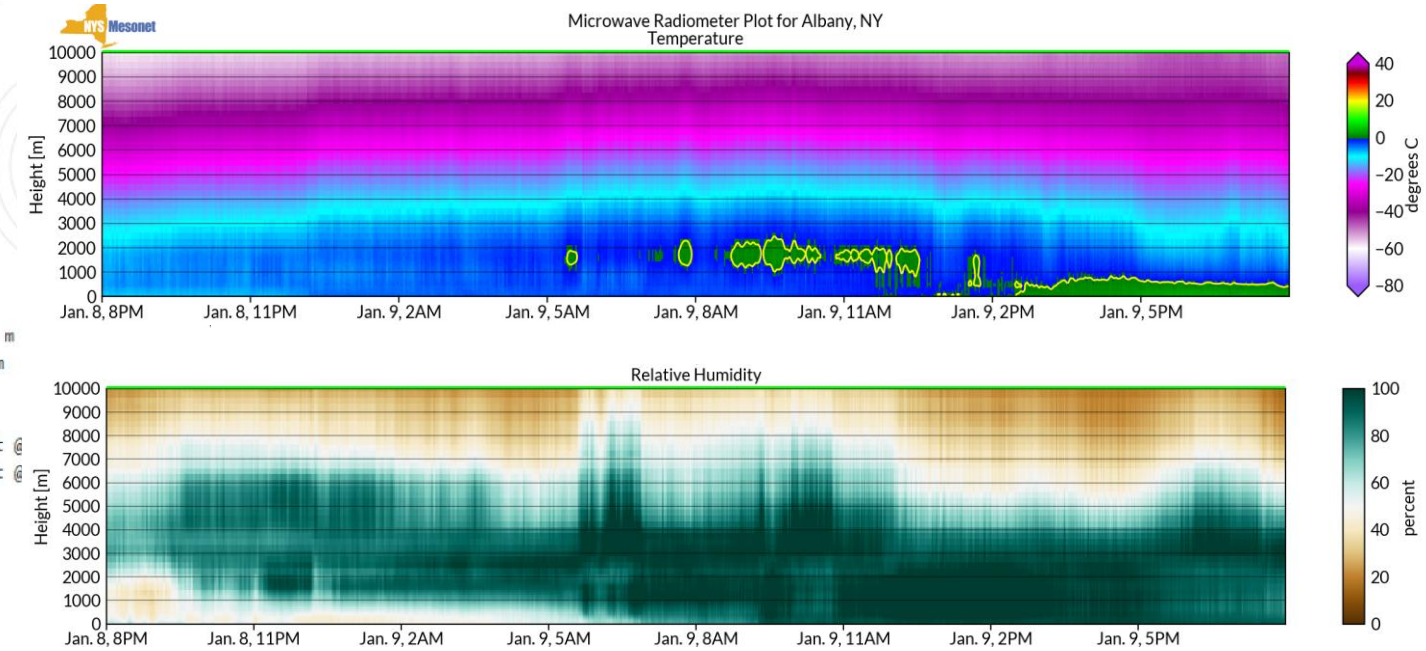
Results: Wintry Mix Event on 3 – 4 Feb 2022

A long duration winter storm brought all four p-types with 12+ hours of SLT (2 inches) at Albany, NY





Application: Real-time p-type monitoring



Available at: http://www.nysmesonet.org/networks/profiler#stid=prof_alba

Conclusion

- Both mPING and ASOS agree well on RA and SN but show some discrepancies in FZR and SLT reports **(due to observer and instrumental biases, and spatial and temporal variability)**
- MWR provides high reliability on RA and SN and a reasonable accuracy on FZR and SLT compared to both mPING and ASOS
- MWR over-forecasts FZR and under-forecasts SLT but comparatively better to ASOS than mPING
- Inconsistencies in MWR FZR and SLT forecasts due to mPING biased towards SLT and away from FZR, ASOS under-reporting of SLT and may be due to FZR biased collapse scheme applied

Conclusion

- MWR can capture high-temporal p-type transition (10 min) and provide profile data to better understand/monitor thermodynamic changes taking place aloft affecting the p-type at the surface
  - A much-needed information not available from ASOS, mPING or CoCoRaHS and significant advantages over twice daily NWS radiosondes
- MWR p-type retrievals can be further improved with the refinement of parcel thickness method or applying robust, explicit temperature dependent area method (Bourgouin, 2000)

Any questions?

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