AN EVALUATION OF PRECIPITATION ESTIMATES ASSOCIATED WITH IDA IN THE NORTHERN MID-ATLANTIC REGION FOR A FORENSIC CASE

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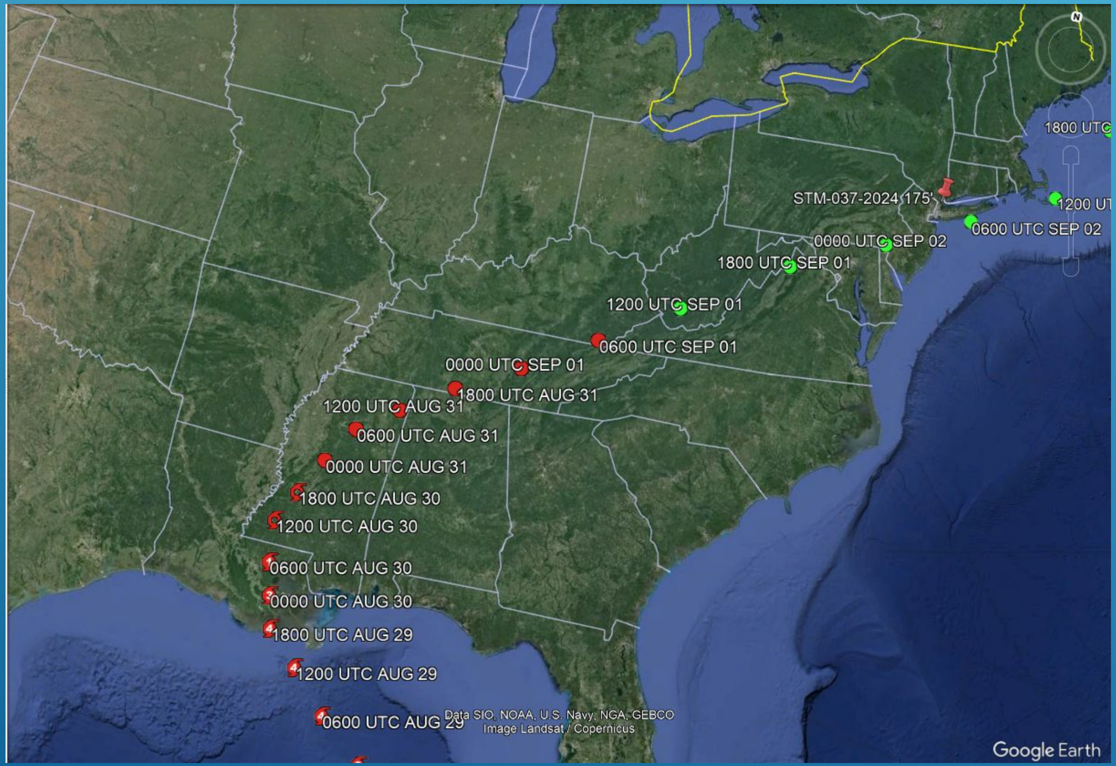
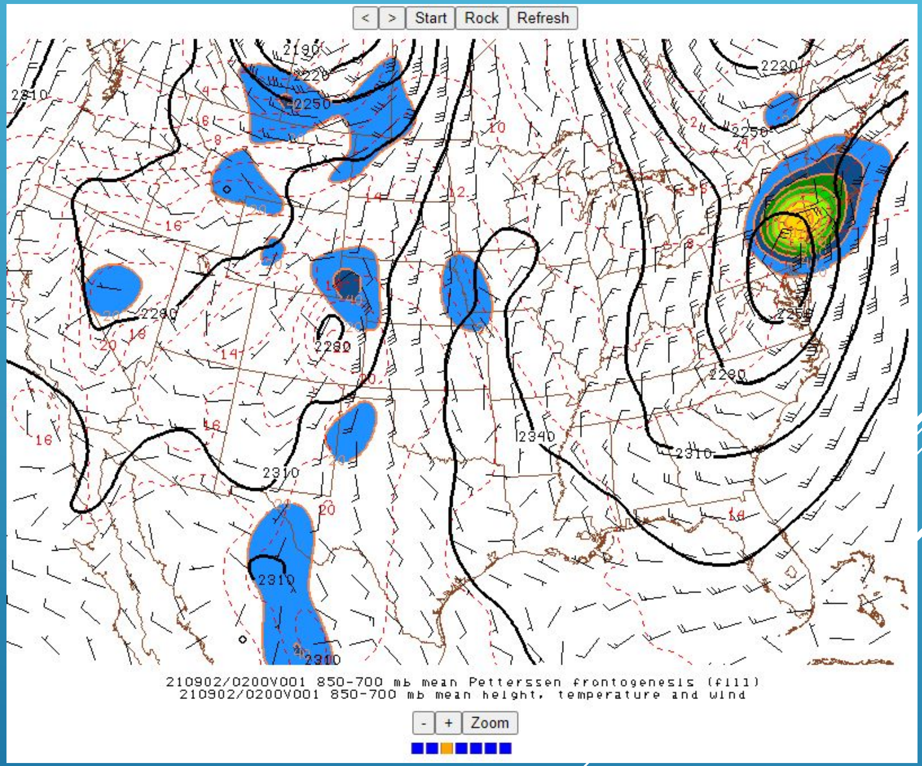
STM Weather

IDA TRACK AND 850-700 MB FRONTOGENESIS



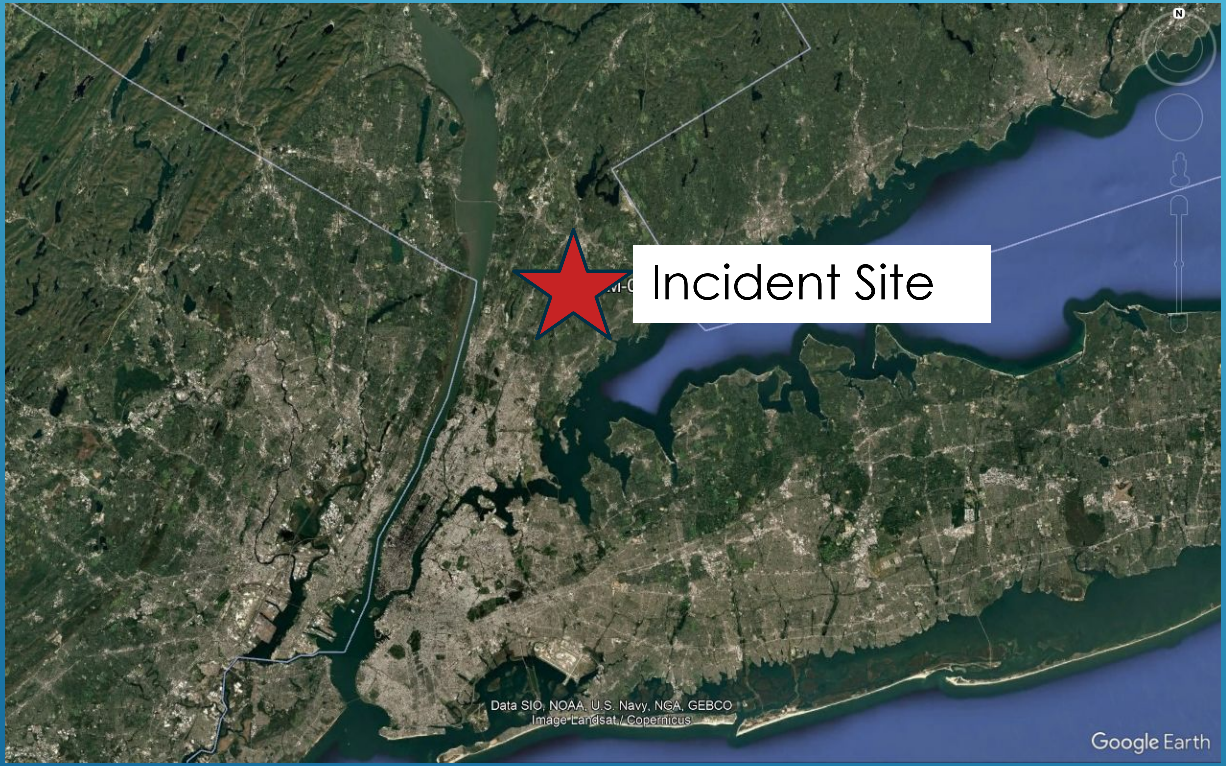


FLOODING FROM IDA IN NEW YORK CITY AND THE SUBURBS

New York subway

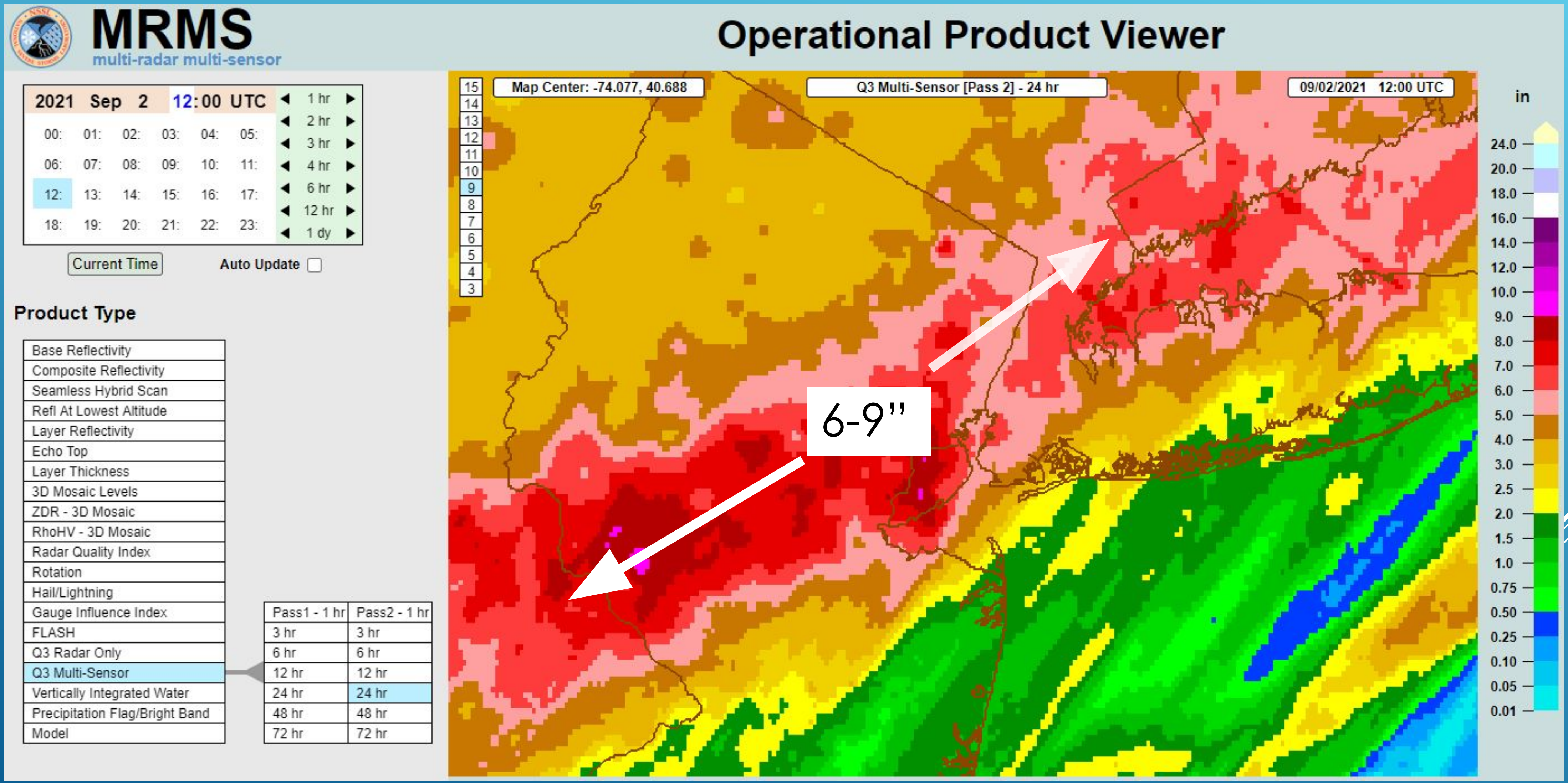
Westchester County

FLOODING INCIDENT LOCATION

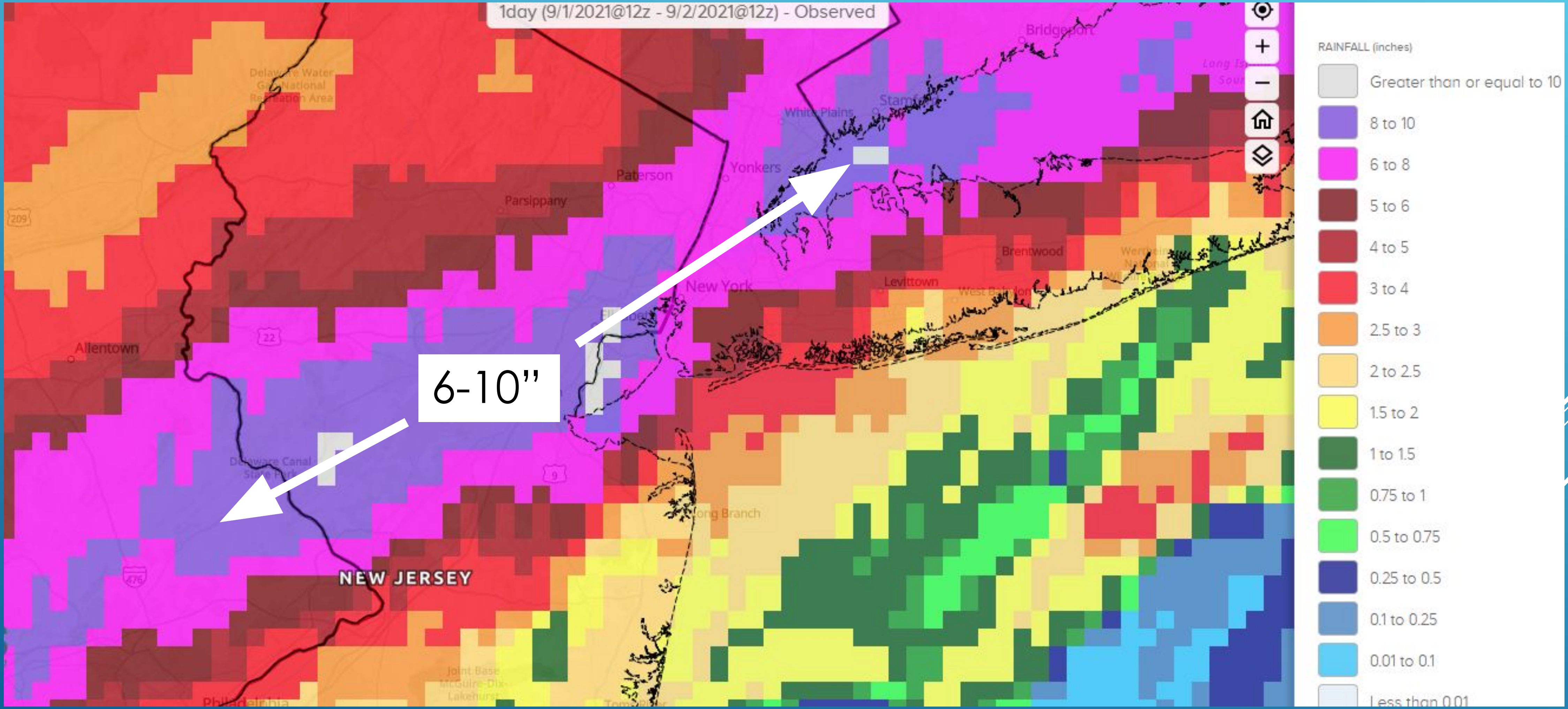


Dam location

MRMS RAINFALL ESTIMATES



NATIONAL WEATHER SERVICE RAINFALL ESTIMATES (MOSAICED FROM RFC'S – MRMS / HUMAN MIX ESTIMATES)



RAINFALL VS CLIMATOLOGY

- A 200-year one-hour rainfall event at NYC (3.47" from 9 to 10 PM) (chance for exceedance in a give year was 1/200 or 0.5 percent)
- A 50-year one-hour rainfall event at LGA (2.80" from 9 to 10 PM) (chance for exceedance in a given year was 1/50 or 2 percent)
- Less than a 50-year one-hour rainfall at HPN (2.03" from 10 to 11 PM)
- Rainfall was less than a 50-year 24-hour rainfall event at NYC (7.13")
- Rainfall was less than a 50-year 24-hour rainfall event at LGA (6.80")
- Rainfall was less than a 50-year 24-hour rainfall event at HPN (6.06")

MRMS QPE DETERMINATION – STEP ONE: DETERMINE PRECIPITATION RATE FROM MOSAICED REFLECTIVITY

MRMS QPE determination…

- https://vlab.noaa.gov/web/wdtd/mrms-products-guide
  - Reflectivity from multiple radars
  - The surface precipitation rate (SPR) product uses reflectivity plus a combination of dual-pol and non-dual pol reflectivity / rainfall rate relationships based on location with respect to the melting later

Above the melting level

Surface Precip Type	Z-R Relationship	Rate Cap
Warm stratiform rain	$Z = 75R^{2.0}$ when $Z < 40$ dBZ	1.9 in/hr
Cool stratiform rain	$Z = 200R^{1.6}$ when $Z \geq 40$ dBZ	
Convective rain	$Z = 300R^{1.4}$	4.1 – 5.9 in/hr
Hail	$Z = 300R^{1.4}$	2.1 – 5.9 in/hr
Snow	$Z = 75R^{2.0}$	none
Tropical Stratiform	$Z = 250R^{1.2} / \beta^{1.2}$ $Z = \max\{75R^{2.0}, 200R^{1.6}\}$	varies, up to 8.7 in/hr
Tropical Convective	$Z = 250R^{1.2} / \beta^{1.2}$ $Z = 300R^{1.4}$	

Z = reflectivity
R = rainfall rate

Below the melting level

Conditions		Rain Rate Relationship	Rate Cap	Applications
$Z < 48$ dBZ	Below the bottom of the ML	$R = 4120A^{1.03}$ (if φ_{DP}_span ≥ 3°)	7.9 in/hr	Pure, steady rain (i.e. no ice, hail)
		max{ R(A) , R(Z) } where R(Z): $Z = 75R^{2.0}$ (east of 105W) $Z = 200R^{1.6}$ (west of 105W)	varies	Very light, sporadic, stratiform rain
$48 \leq Z < 50$ dBZ		Weighted mean of R(A) and R(K_{DP}) (linear weight of function of Z)	varies	---
$Z \geq 50$ dBZ		$R = 29\|K_{DP}\|^{0.770}$ (CC < 0.97) $R = 44\|K_{DP}\|^{0.822}$ (CC ≥ 0.97)	4.9 in/hr 6.9 in/hr	Areas of potential hail & heavy rain
---	50 km transition zone from bottom of ML	Weighted mean of R(A) and R(Z) where R(Z) is based on SPT	varies	---
---	Above the bottom of the ML	R(Z) where R(Z) is based on SPT	see previous slides	Within & above the ML

- QPE “radar only” determined for different time lengths by adding the SPR products
- QPE multi-sensor is then determined

MRMS QPE DETERMINATION – STEP TWO: ADJUST QPE WITH GAGES

MRMS product definitions - https://vlab.noaa.gov/web/wdtd/mrms-products-guide

Adjust radar only QPE with gages using weighting by distance between gage and grid point estimate

- Multi-sensor QPE (under "Most useful products")
  - The Gauge Quality Control is first conducted to rid of any gauges that may cause erroneous estimates due to factors such as frozen precipitation, untimeliness of reporting, and anomalously high/low values.
  - At each remaining rain gauge, find the difference between the co-located one-hour radar QPE and the gauge observation (i.e. the error at the rain gauge).
  - We assume that the surrounding radar estimates are also biased (not just at the gauge), so we interpolate the estimated radar error at every radar pixel within a radius of influence using an inverse distance weighting (IDW) scheme. The IDW scheme considers: 1) the distance of the gauge from the radar pixel, and 2) the density of the gauge network.
  - If the distance (d) between the rain gauge and pixel is within the range of influence (D), a weight (w) is calculated. The closer the proximity, the higher the weight. If d is greater than D, then the weight will equal zero.

MRMS QPE DETERMINATION – STEP THREE: USE NWP AND MOUNTAIN MAPPER IN AREAS OF POOR RADAR COVERAGE

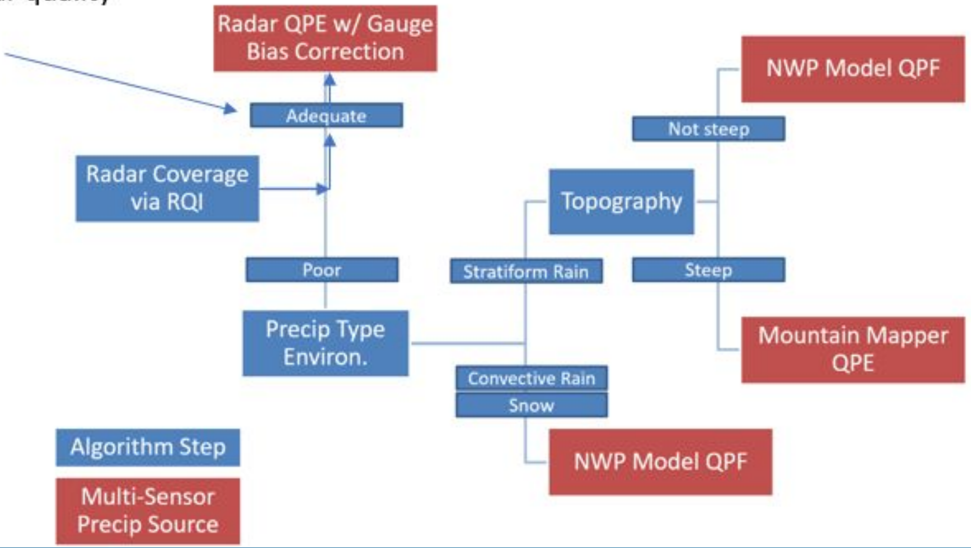
QPE estimations

Description of flow chart below

There are significant radar coverage gaps across the western CONUS and in other MRMS domains (e.g., Alaska). To supplement the radar data, the new Multi-Sensor QPE utilizes a combination of gauges (via Mountain Mapper QPE) and NWP (HRRR/RAP blend for CONUS) to gap-fill in poor radar coverage areas.

1. The logic uses the Radar QPE w/ Gauge Bias Correction as the primary precipitation source with its weight in the scheme defined by the RQI product.
2. Beyond the areas using radar coverage, the combination of Mountain Mapper and NWP are dependent on a number of variables.
   1. NWP (via the 1-h forecast QPF) is utilized in snow environments and also in stratiform rain environments over areas of non-complex terrain.
   2. Mountain Mapper QPE is utilized in areas of stratiform rain over areas of complex terrain.
3. Each source is seamlessly blended to avoid any discontinuities in the data.

RQI=radar quality index



RQI at a point: a function of height of the beam with respect to the freezing level (ie distance from radars), and blocking. https://vlab.noaa.gov/web/wdtd/-/radar-quality-index-rqi-

Is the radar quality typically adequate in the northeast CONUS?

RADAR QUALITY INDEX (WINTER LEFT, SUMMER RIGHT)

Example RQI values

February

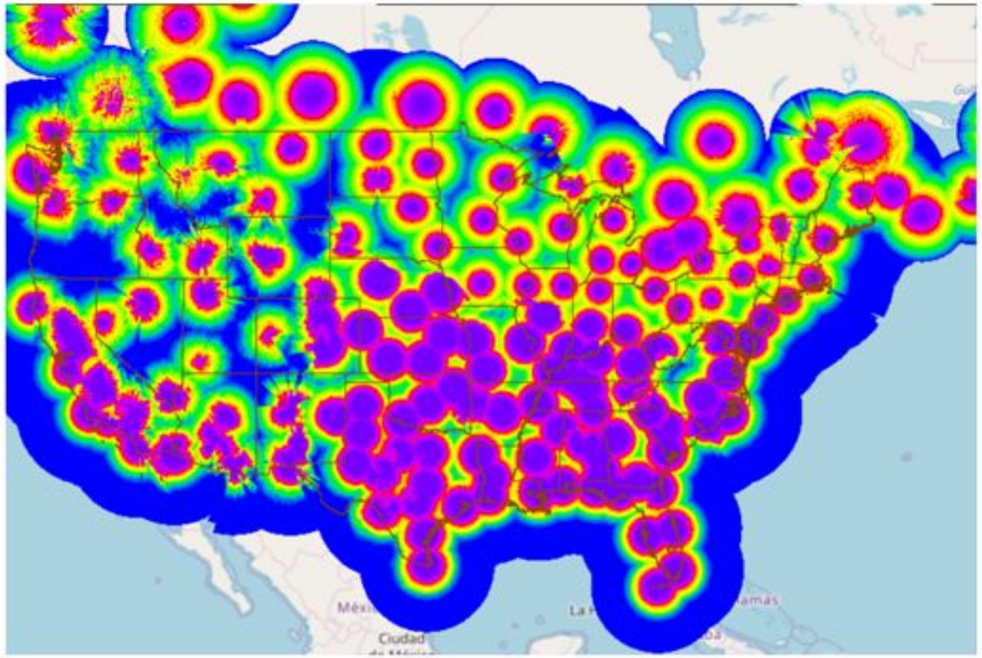


Figure 3. An example of the Radar Quality Index (RQI) product for February 2019. Cool colors denote regions of high QPE uncertainty due to 1) beam blockage and 2) the radar beam position with respect to a low freezing level.

August

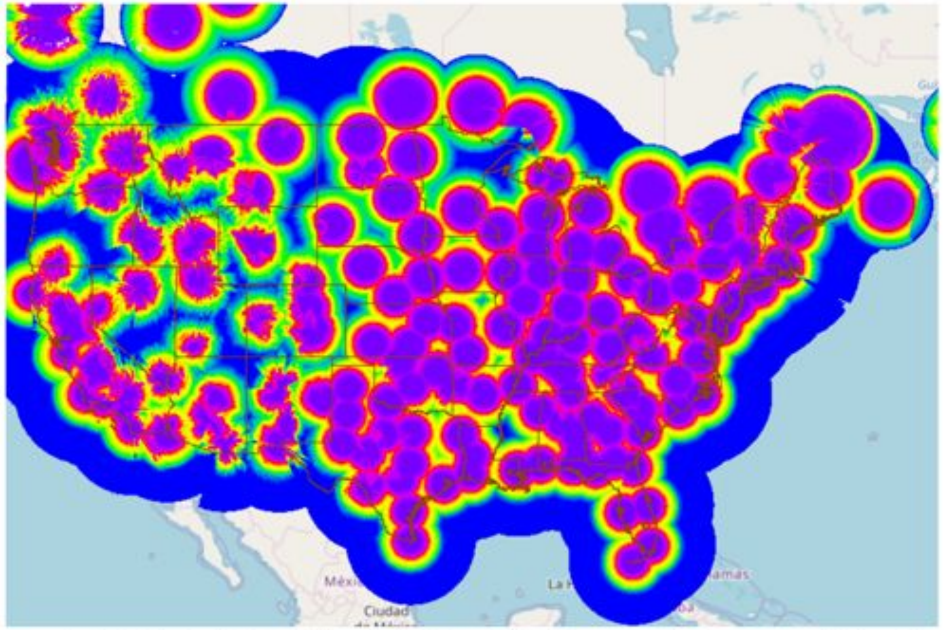
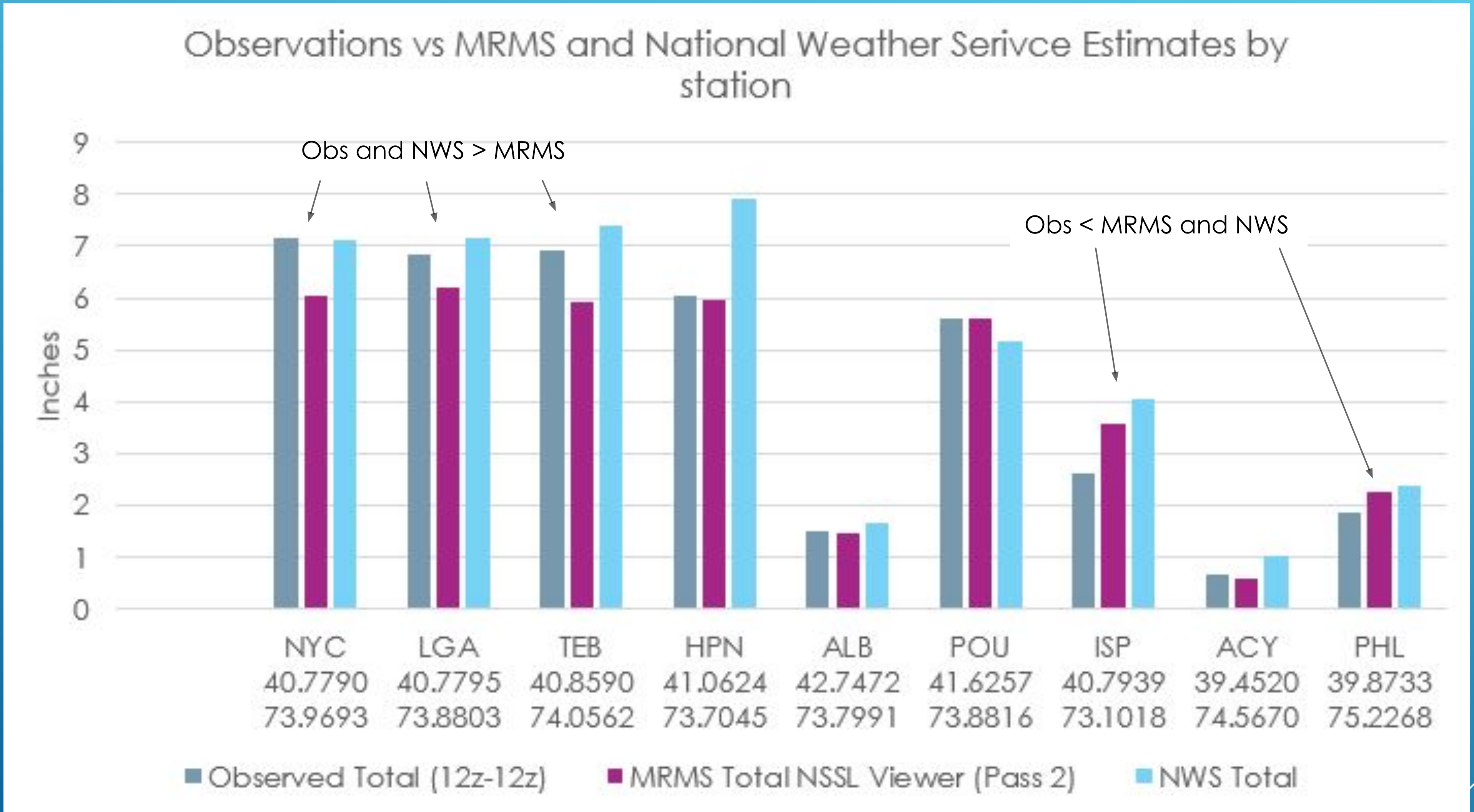
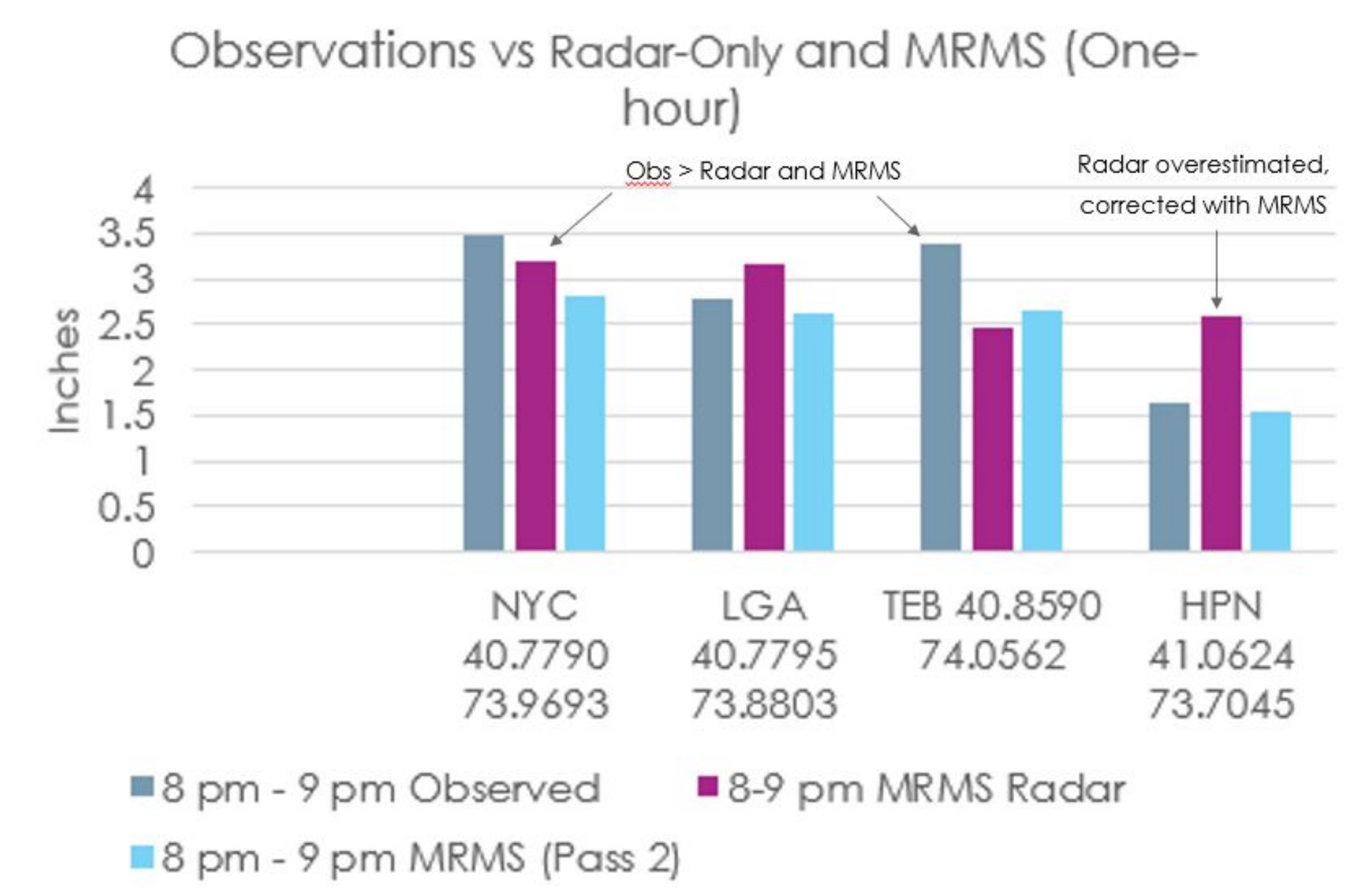


Figure 4. An example of the Radar Quality Index (RQI) product for August 2019. This is an example of a warm season RQI map. Warm colors denote regions of low QPE uncertainty due to minimal blockage and the radar beam position being (generally) below the freezing level. Note how there are still issues in the West due to complex terrain.

HOW GOOD WERE THE MRMS ESTIMATES?



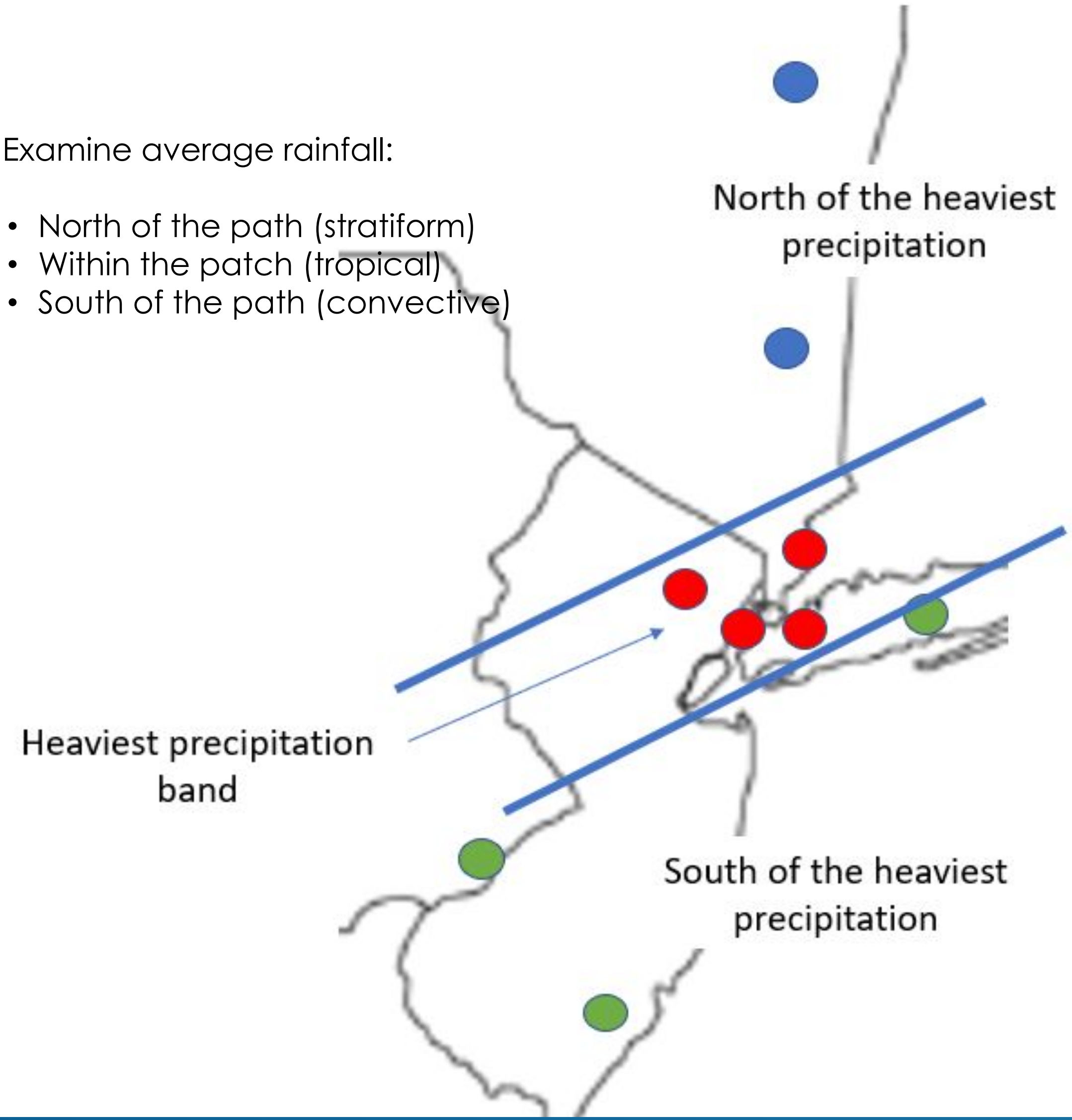


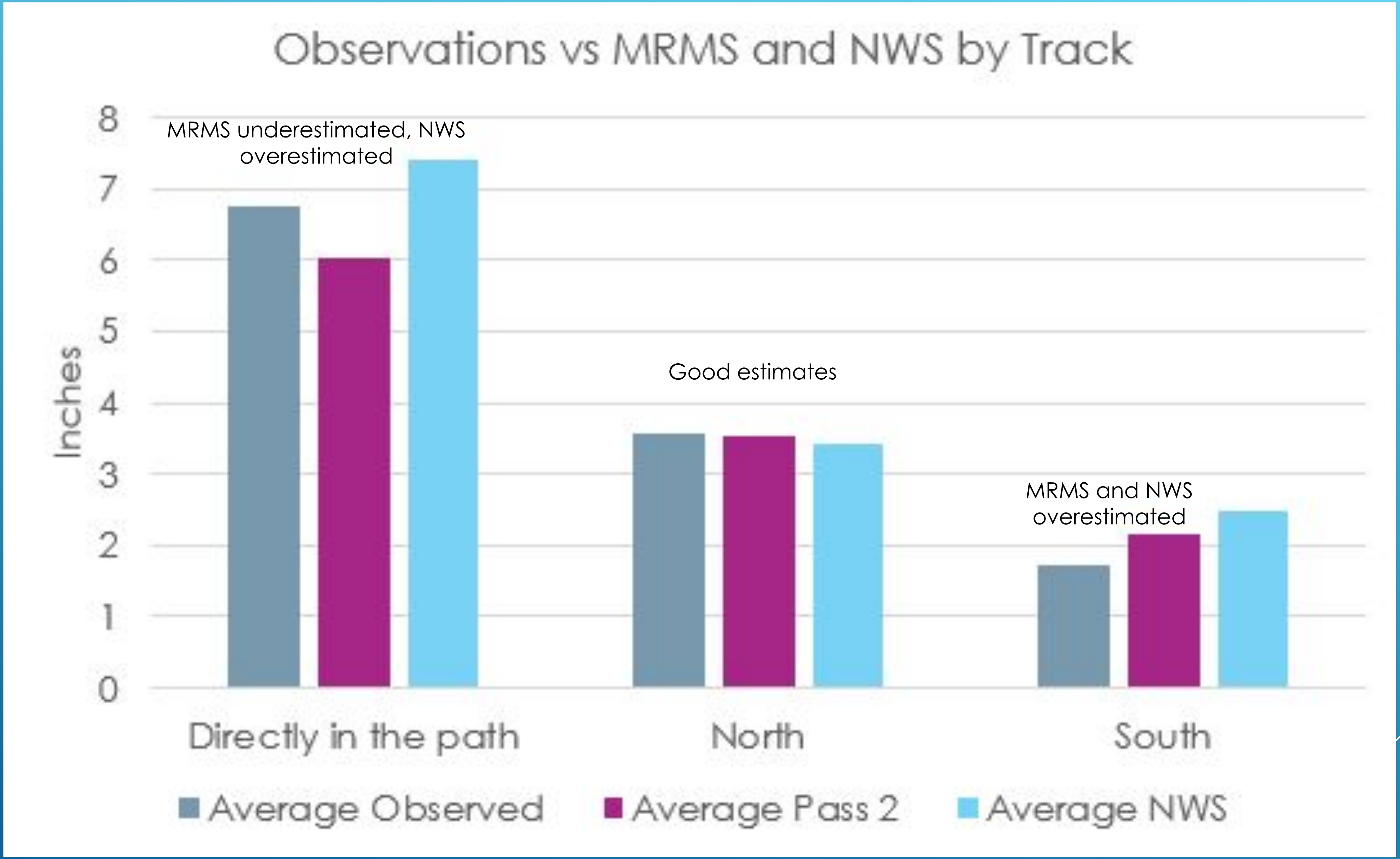
Observations vs Radar-Only and MRMS (One-hour)
Obs > Radar and MRMS
Radar overestimated, corrected with MRMS
Inches
4
3.5
3
2.5
2
1.5
1
0.5
0
NYC 40.7790 73.9693
LGA 40.7795 73.8803
TEB 40.8590 74.0562
HPN 41.0624 73.7045
8 pm - 9 pm Observed
8-9 pm MRMS Radar
8 pm - 9 pm MRMS (Pass 2)

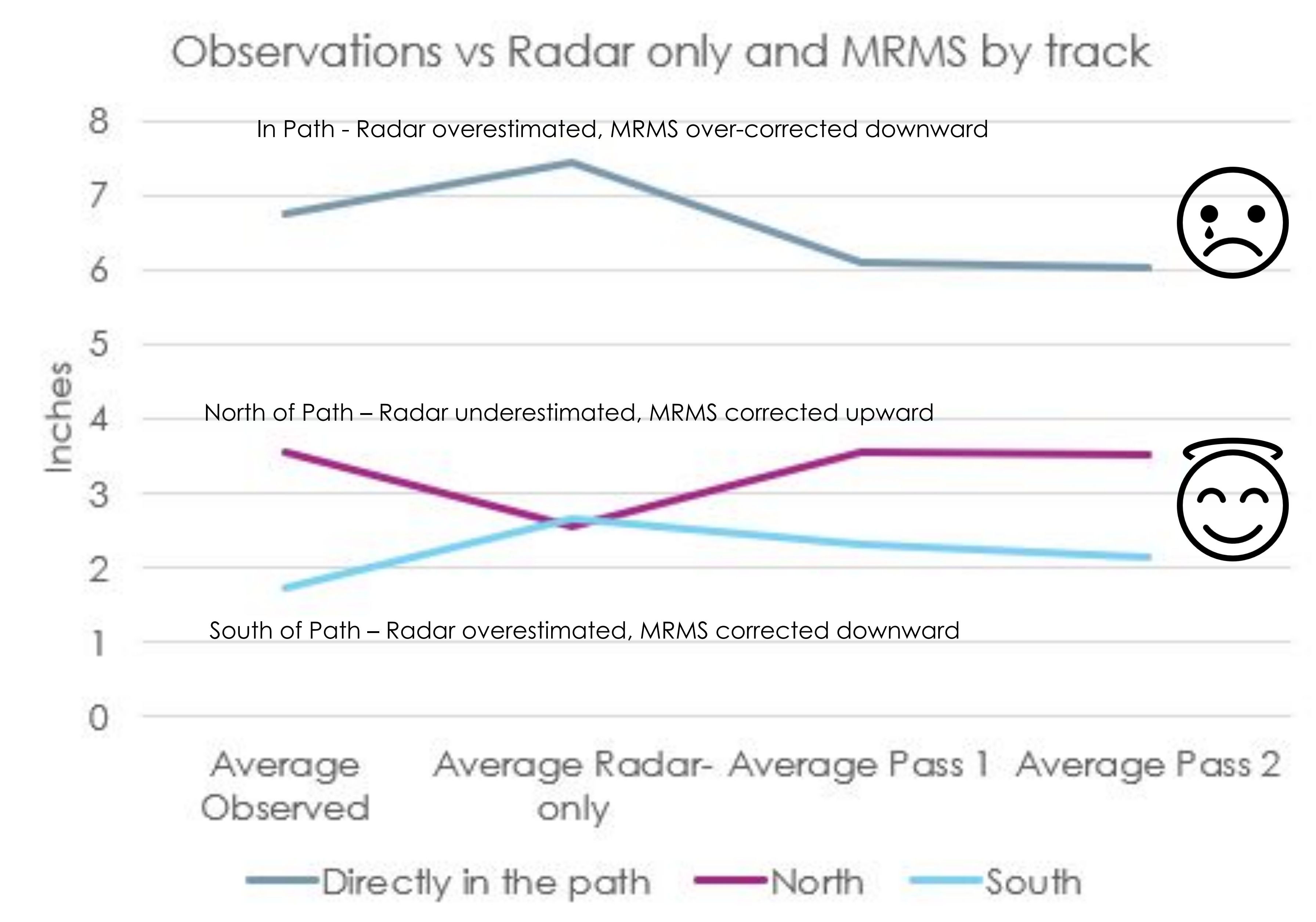
IMPACT OF LOCATION ON MRMS QUALITY

Examine average rainfall:

- North of the path (stratiform)
- Within the patch (tropical)
- South of the path (convective)




Observations vs MRMS and NWS by Track
MRMS underestimated, NWS overestimated
Good estimates
MRMS and NWS overestimated
Inches
0
1
2
3
4
5
6
7
8
Directly in the path
North
South
Average Observed
Average Pass 2
Average NWS



Observations vs Radar only and MRMS by track
In Path - Radar overestimated, MRMS over-corrected downward
North of Path – Radar underestimated, MRMS corrected upward
South of Path – Radar overestimated, MRMS corrected downward
Inches
8
7
6
5
4
3
2
1
0
Average Observed
Average Radar-only
Average Pass 1
Average Pass 2
Directly in the path
North
South

CONCLUSIONS

- STM was hired to evaluate rainfall at a location that was significantly impacted by heavy rain from hurricane Ida.
- One-hour rainfall totals were greater than 50-year events (2 percent chance of exceedance in a year).
- Accurate rainfall estimates were critical for our analysis.
- MRMS may have underestimated rainfall amounts within the path of heaviest rainfall.
- NWS estimates appeared to improve on the MRMS system for locations within the path of heaviest rainfall.
- Radar-only estimates were over-corrected downward within the path of heaviest rainfall.
- The MRMS system appeared to more effectively correct radar-only estimates outside the path of heaviest rainfall.

ACKNOWLEDGEMENTS

Alicia Wasula

Kelly Cebulko

THANK YOU!

QUESTIONS?