# Performance of the Freezing Rain Accumulation National Analysis (FRANA) and updates for this winter season

*Daniel D. Tripp[1], Adam D. Werkema[1], Heather D. Reeves[1],Brian Barjenbruch[2], Kris Sanders[3], Kirstin Harnos[5], James Corriea[4,5]*

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*[2]National Weather Service, Omaha, NE*

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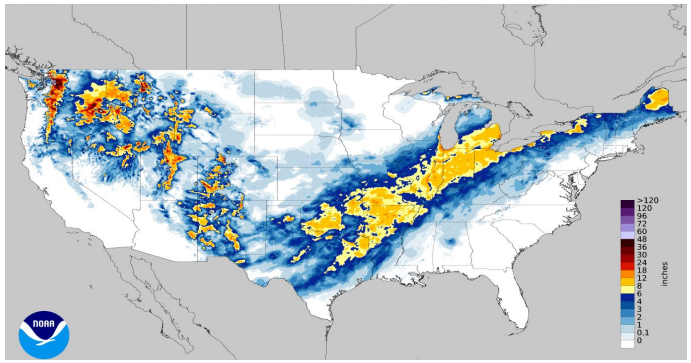
*[4]University of Colorado, CIRES, Boulder, CO*

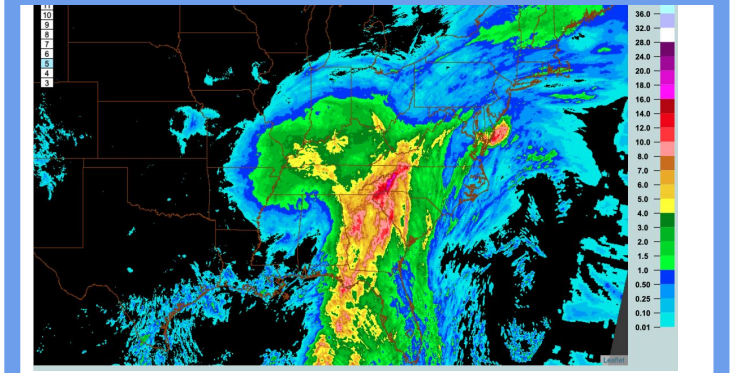
*[5]NOAA/NCEP/Weather Prediction Center, College Park, MD*

# How do we know how much precip fell?

## National Snowfall Analysis




## MRMS QPE (Liquid) or Stage IV



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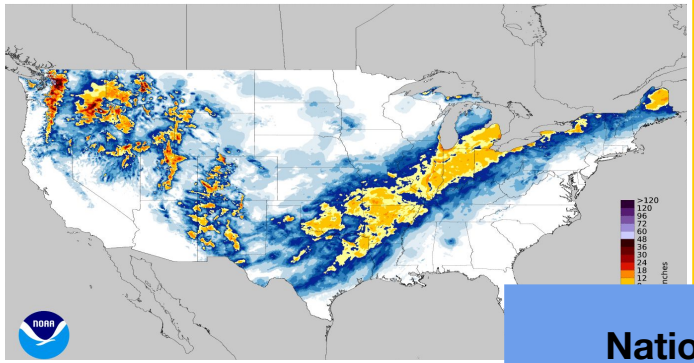


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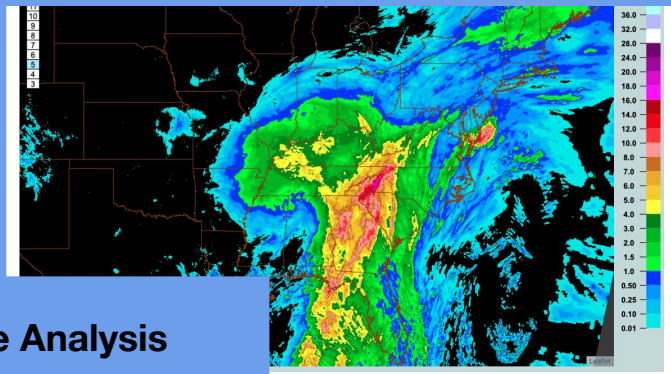
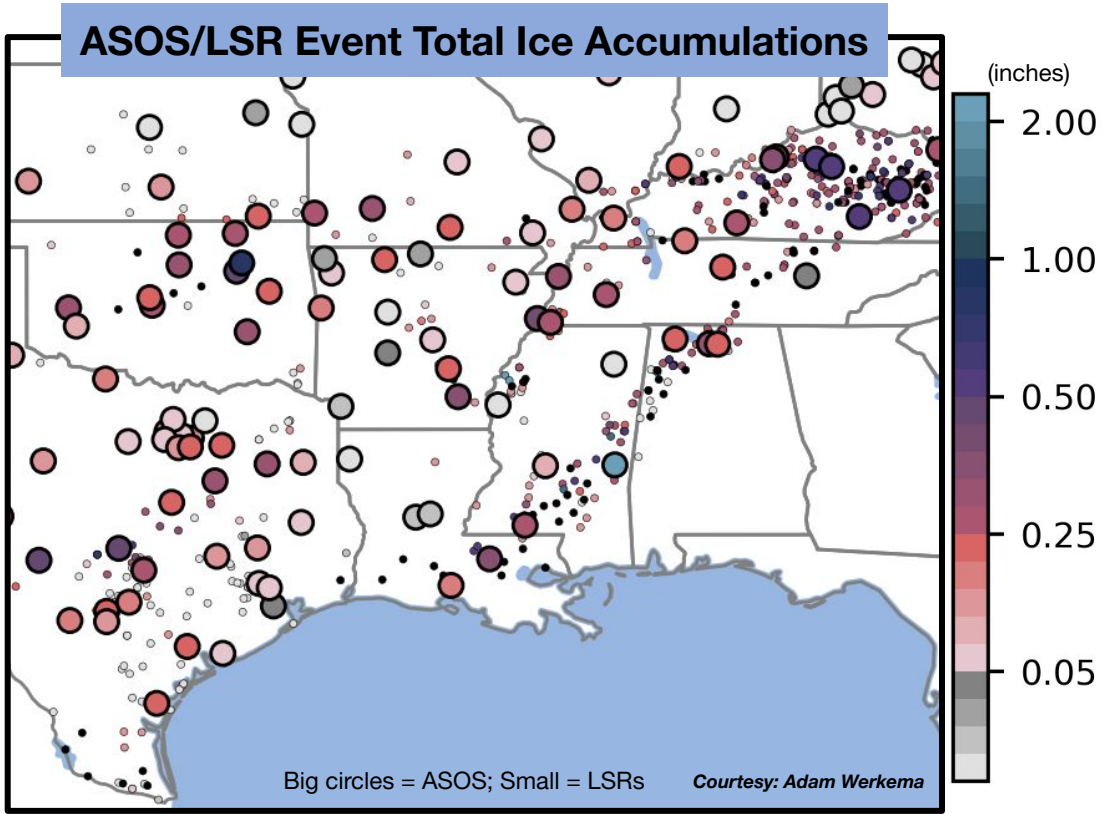



## National Gridded Ice Analysis

?

# How do we know how much ice fell for an event?



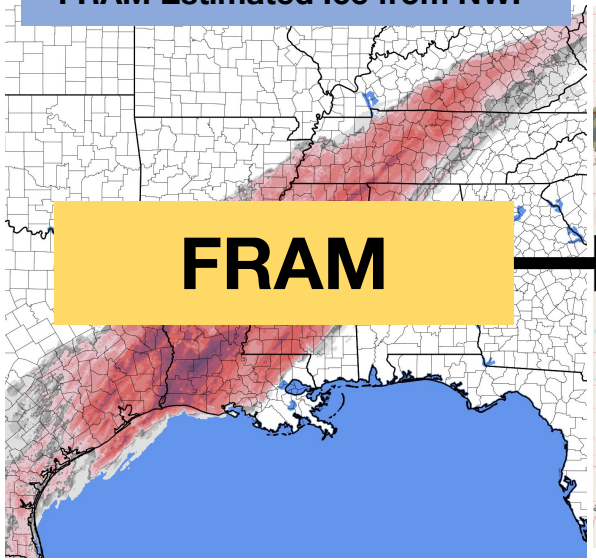

## Verification Data

**Current Products**

- ASOS Goodrich icing sensor
- Local Storm Reports (LSRs)/mPing

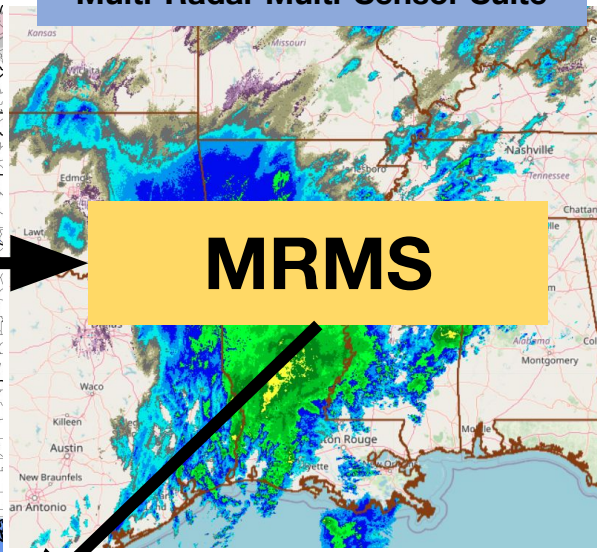
# Freezing Rain Accumulation National Analysis

FRAM Estimated Ice from NWP



FRAM

Multi-Radar Multi-Sensor Suite




MRMS

MRMS Gridded Ice Analysis (FRANA)

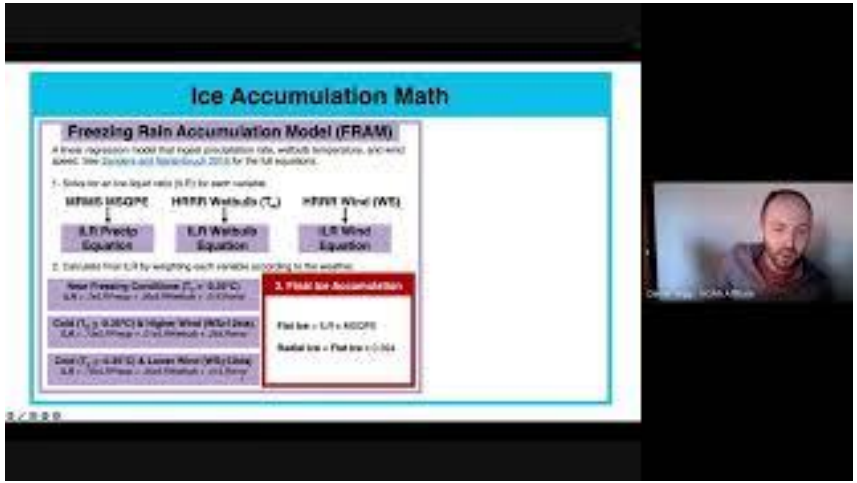
## Verification Data

**Current Products**

- ASOS Goodrich icing sensor
- Local Storm Reports (LSRs)/mPing
- **NEW** FRANA

# Freezing Rain Accumulation National Analysis

## 15-min Overview Video




https://youtu.be/btzn-ObTxKo?si=BdwbRBzb5aANiC6p

## Journal Article

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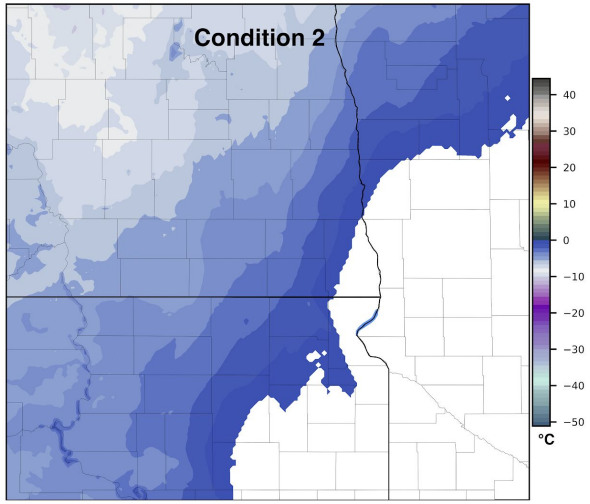
**AMS Weather and Forecasting**

**Anticipating it to be in early online release soon*

(a) HRRR 2m Wetbulb Temperature




# Determining Ice Accumulation Footprint:

a) HRRR 2m $T_{WB} \leq 0°C$

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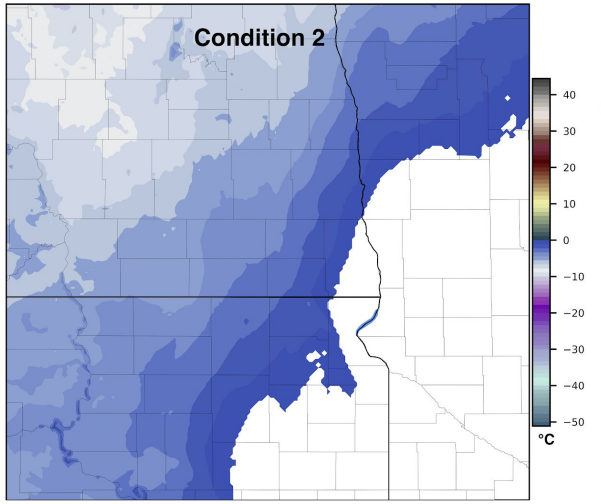
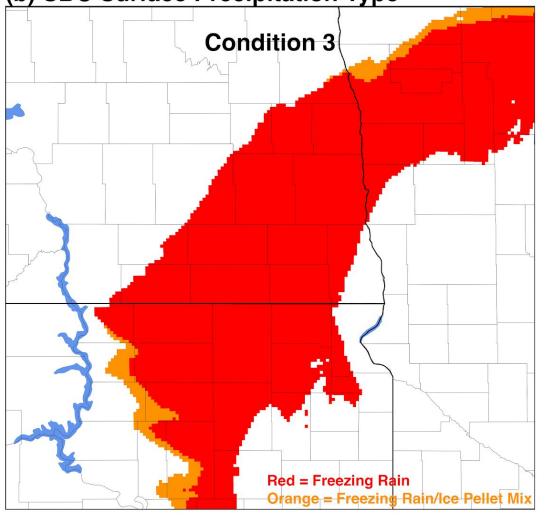



(b) SBC Surface Precipitation Type

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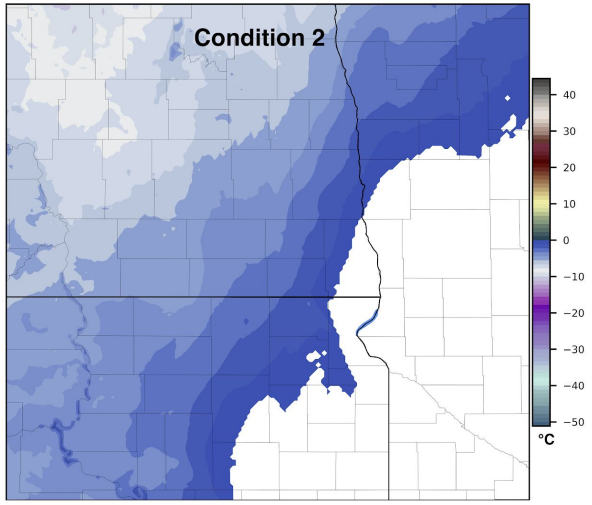


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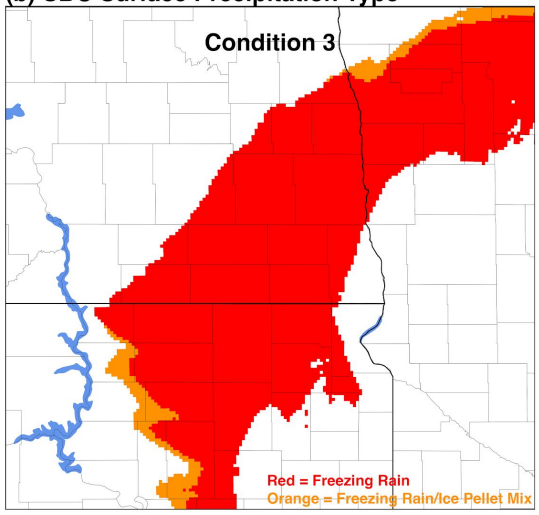
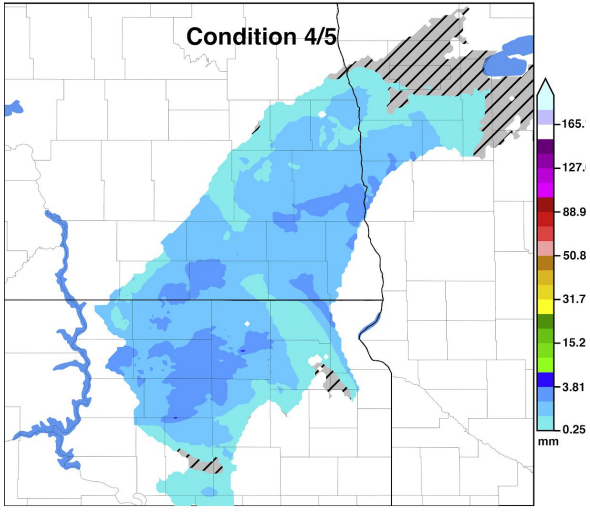



(c) MSQPE (fill) and BREF 1hr Max (hatching)

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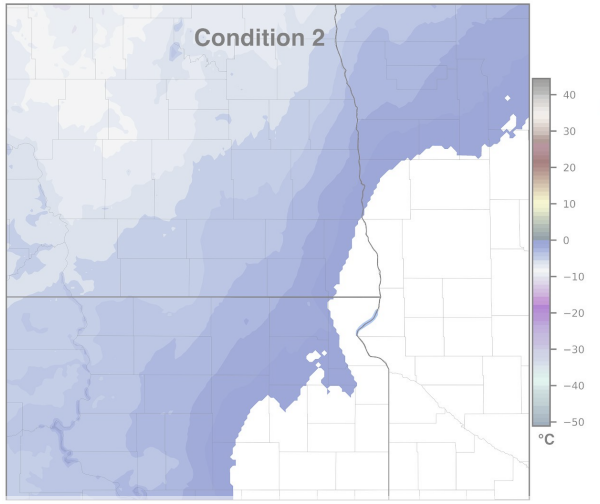


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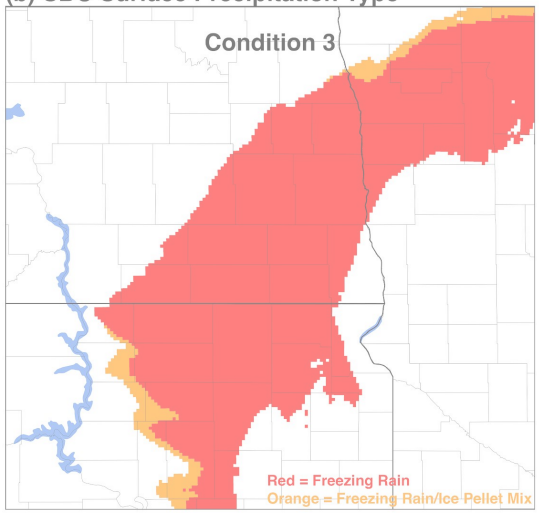


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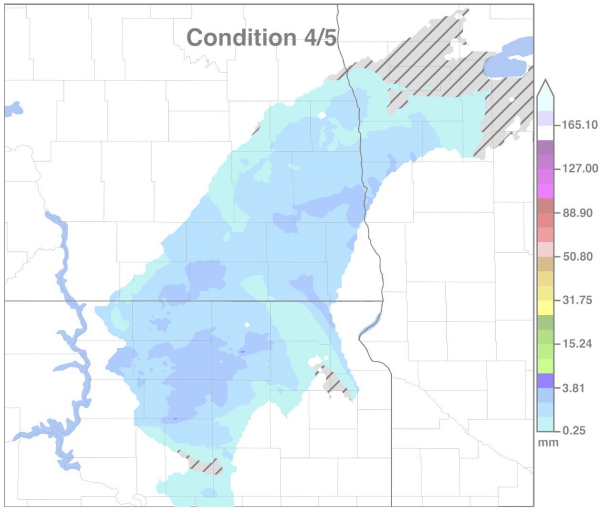
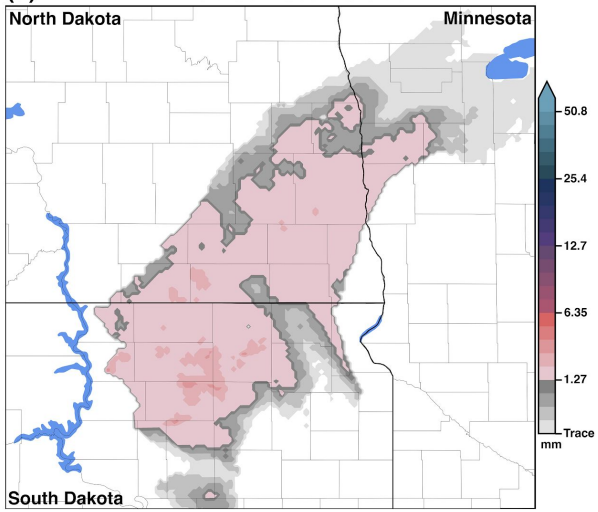



(d) FRANA 1hr Flat Ice Accumulation

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## Accumulations (FRAM Inputs)

1) HRRR 2m $T_{WB}$ (analysis)

2) HRRR 10m Wind Speed (analysis)

3) MRMS Pass 1 Multi-Sensor QPE

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## What did we learn about FRANA?

*(Highlights from the paper)*

- **How skillful is the footprint (spatial coverage) of FRANA?**
- **How skillful are the FRANA accumulations?**

# What We Learned: How skillful is the FRANA footprint?

| 3 winter seasons (2020-2023) | POD | FAR | Bias | HSS |
|---|---|---|---|---|
| Accumulating ice only | | | | |

# What We Learned: How skillful is the FRANA footprint?

| 3 winter seasons (2020-2023) | POD | FAR | Bias | HSS |
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- Why is the FAR high and what can be done to lower it?

# Why is the FAR high? FRANA produces ice where it should not (False Positive)

| | FRANA Trace | FRANA Accumulation |
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| False Positives | | |

# Why is the FAR high? FRANA produces ice where it should not (False Positive)

| | FRANA Trace | FRANA Accumulation |
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| False Positives | 72% | 28% |

Too much trace ice is a problem in FRANA

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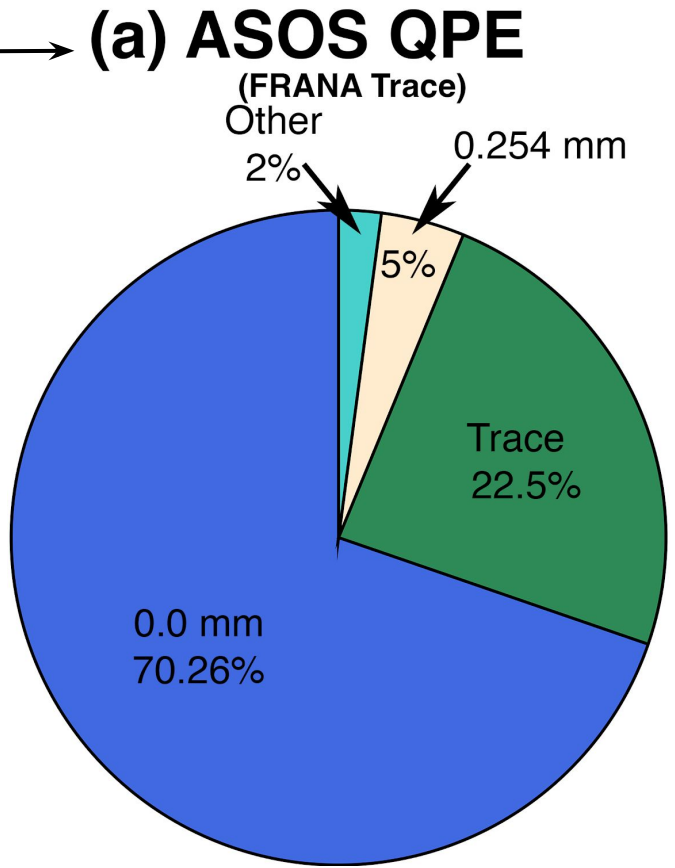

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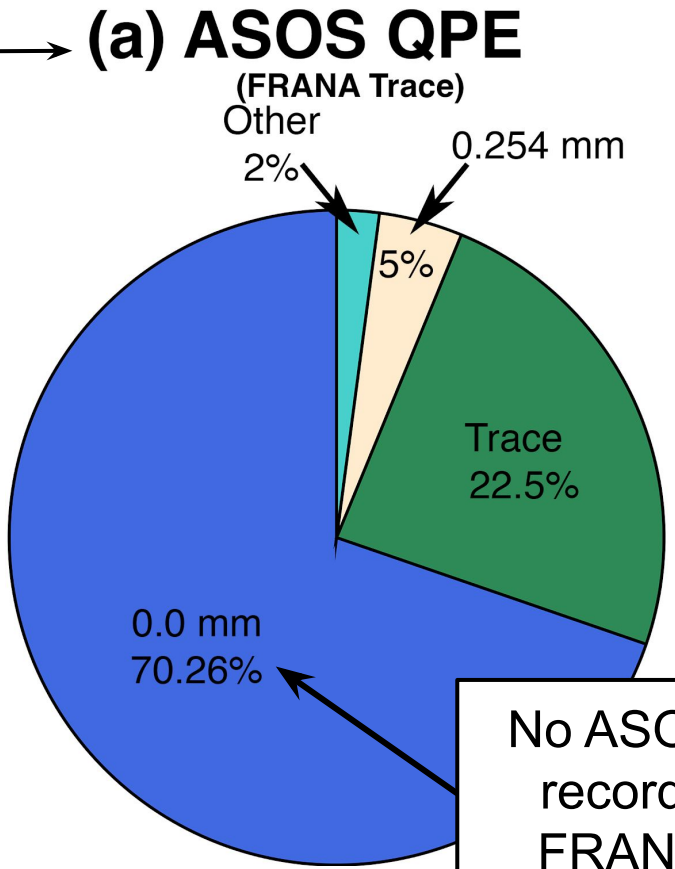


No ASOS precip recorded with FRANA Trace

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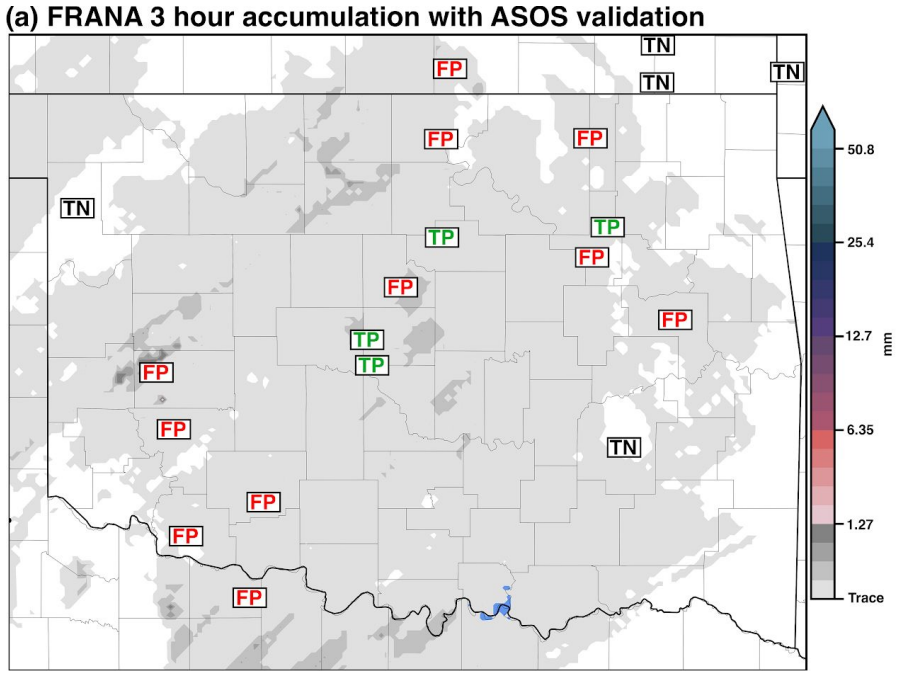


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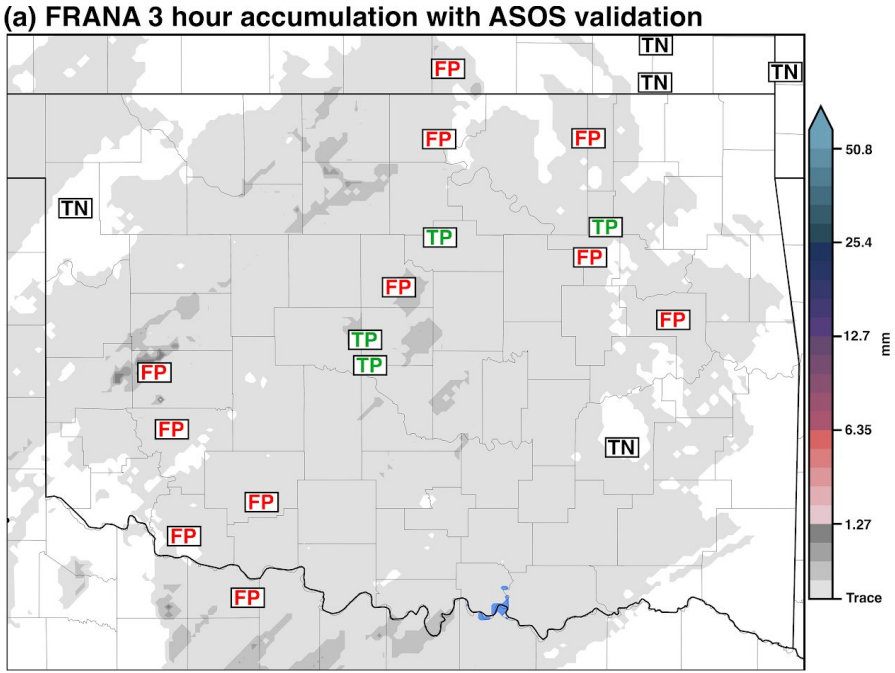


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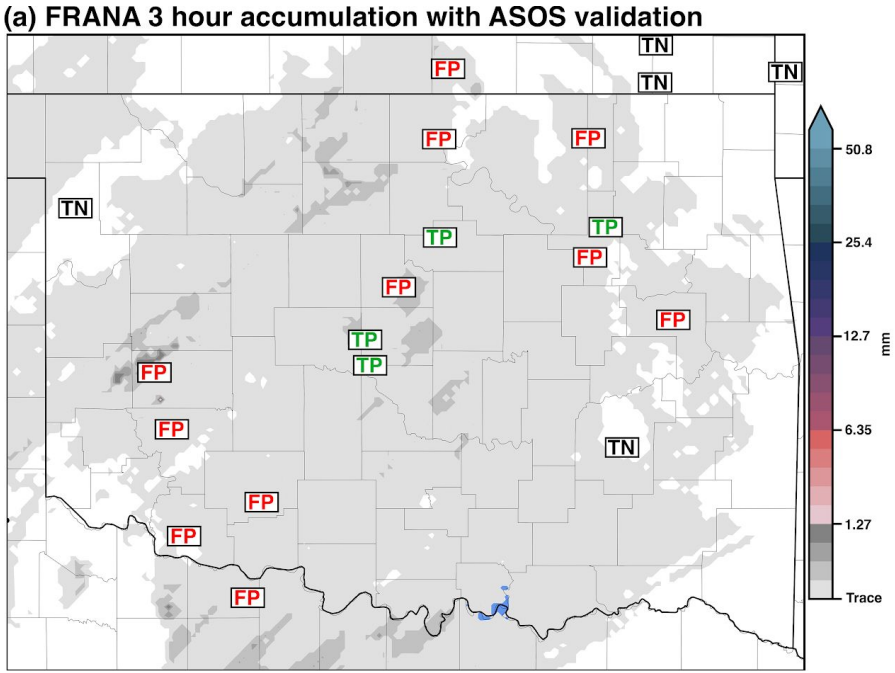


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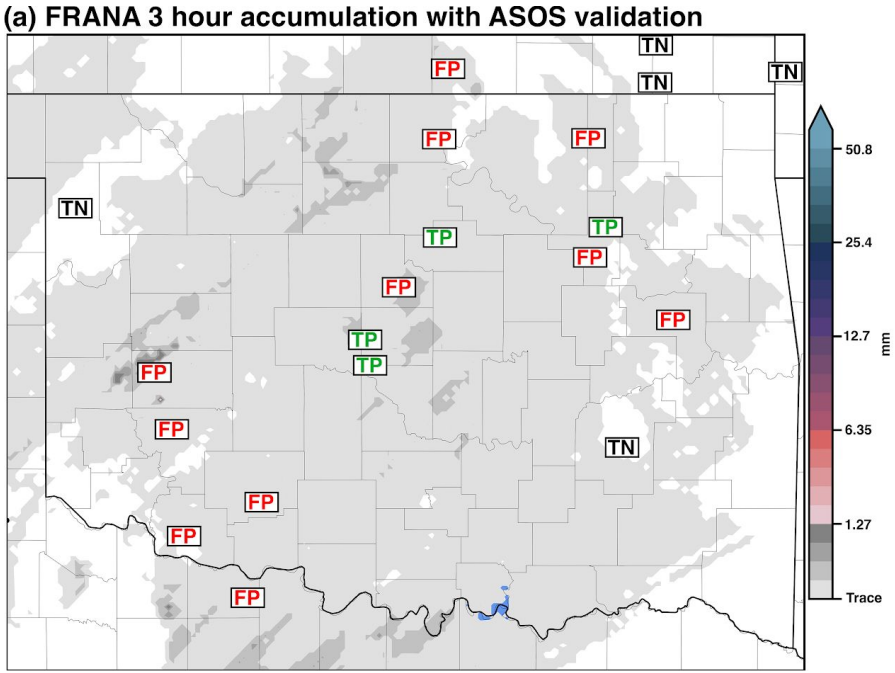


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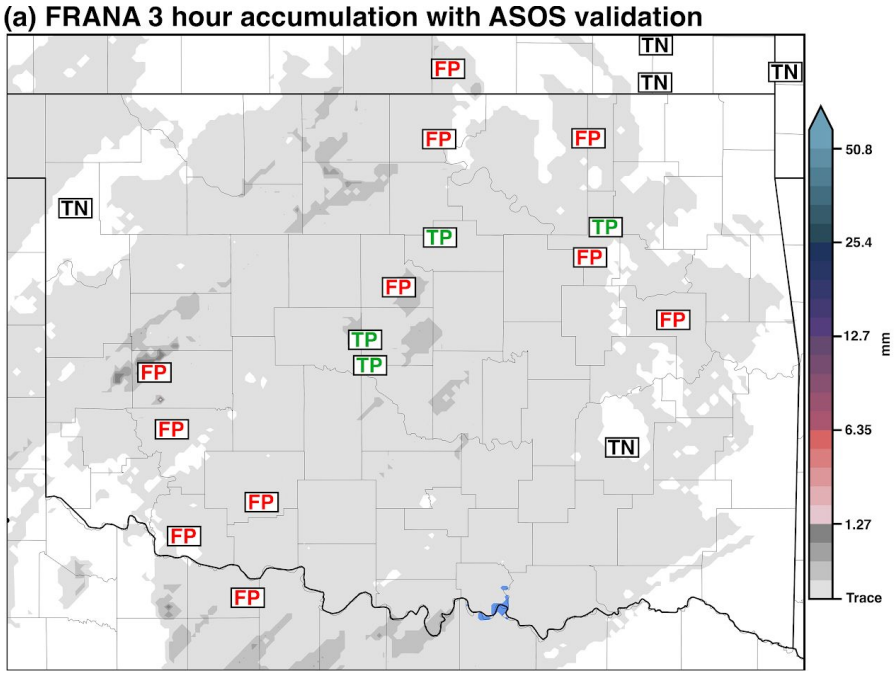


- Freezing rain was very spotty for the onset of this large event.
- **Recall:** Trace ice can only be declared where radar detects precip on the base scans
- The HRRR model analyses were able to resolve the drier air near the surface which was likely scavenging any precip
- Enforcing a dewpoint depression rule helps

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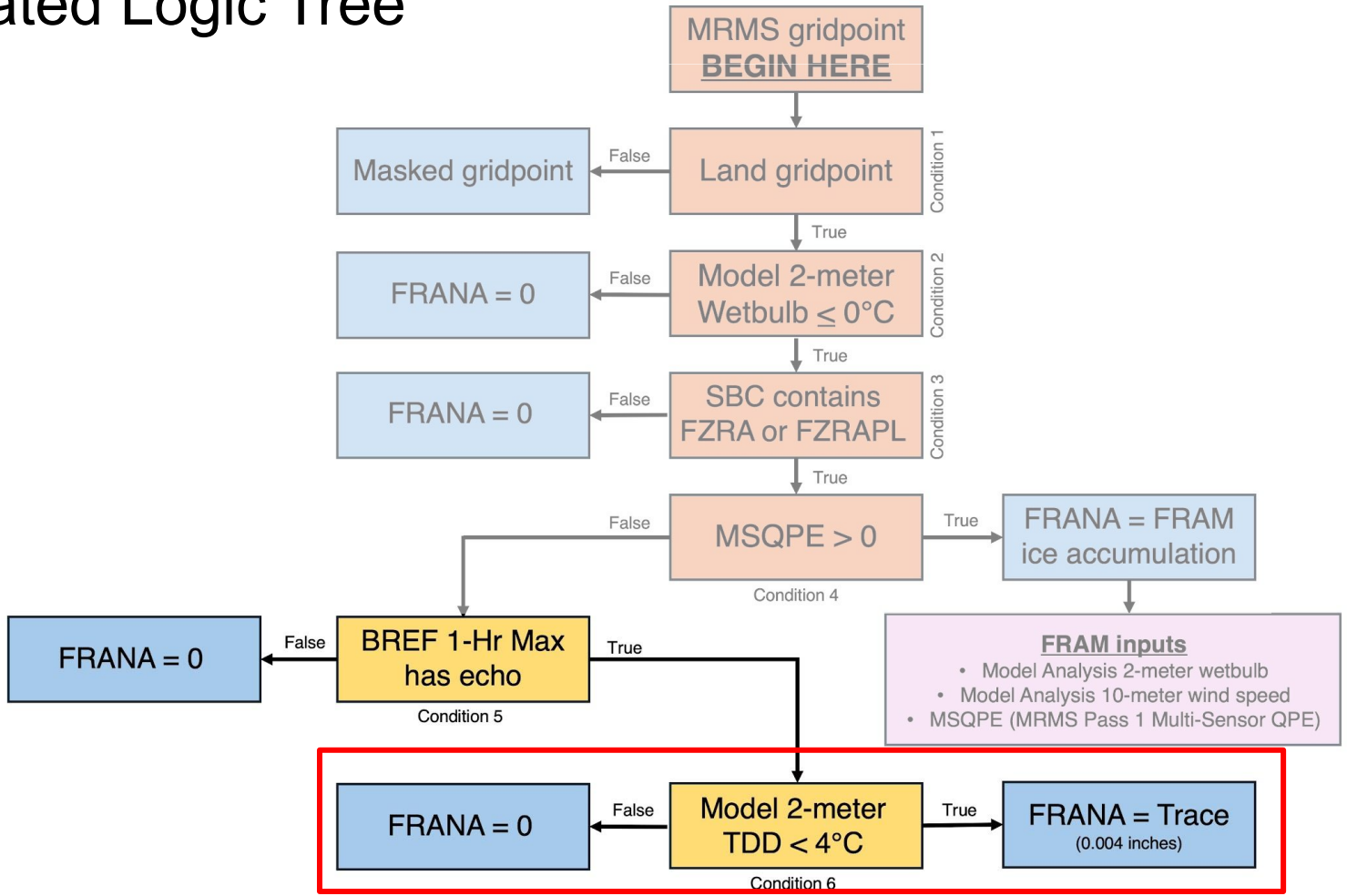
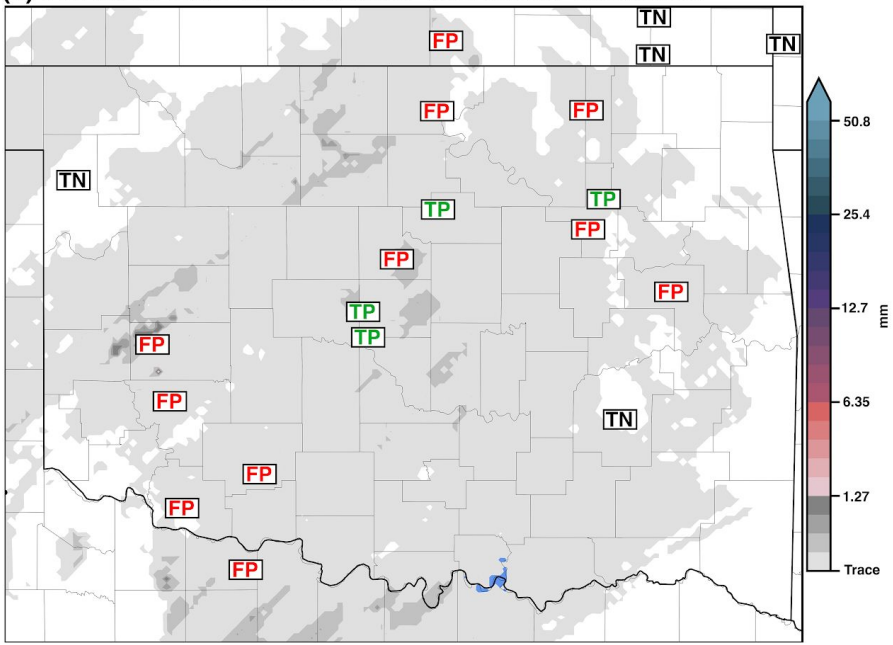
# Updated Logic Tree



# Why is the FAR high? FRANA Chronically Produces Too Much Trace Ice

*New rule: Dewpoint depression must be < 4°C to get trace ice*

(a) FRANA 3 hour accumulation with ASOS validation

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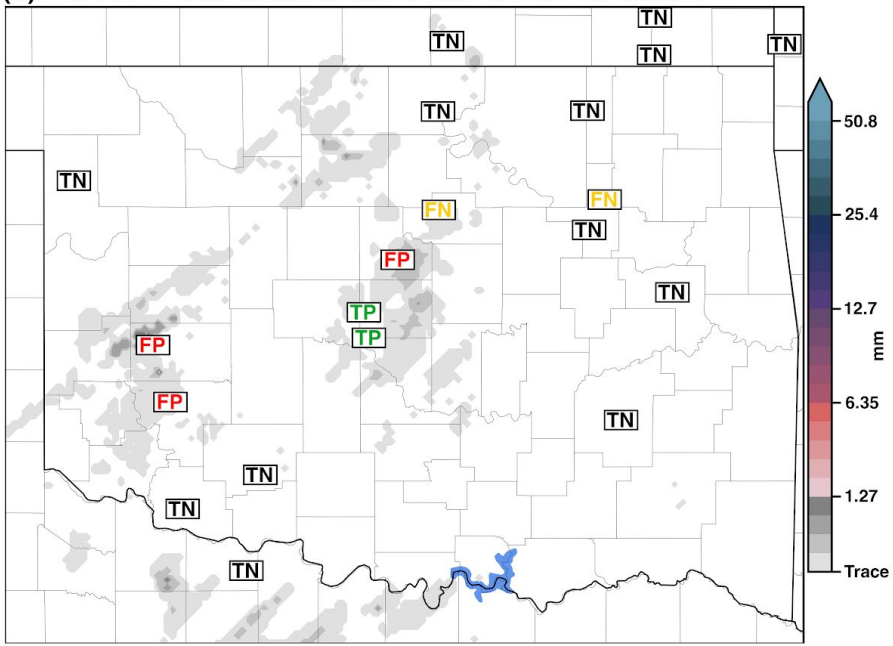


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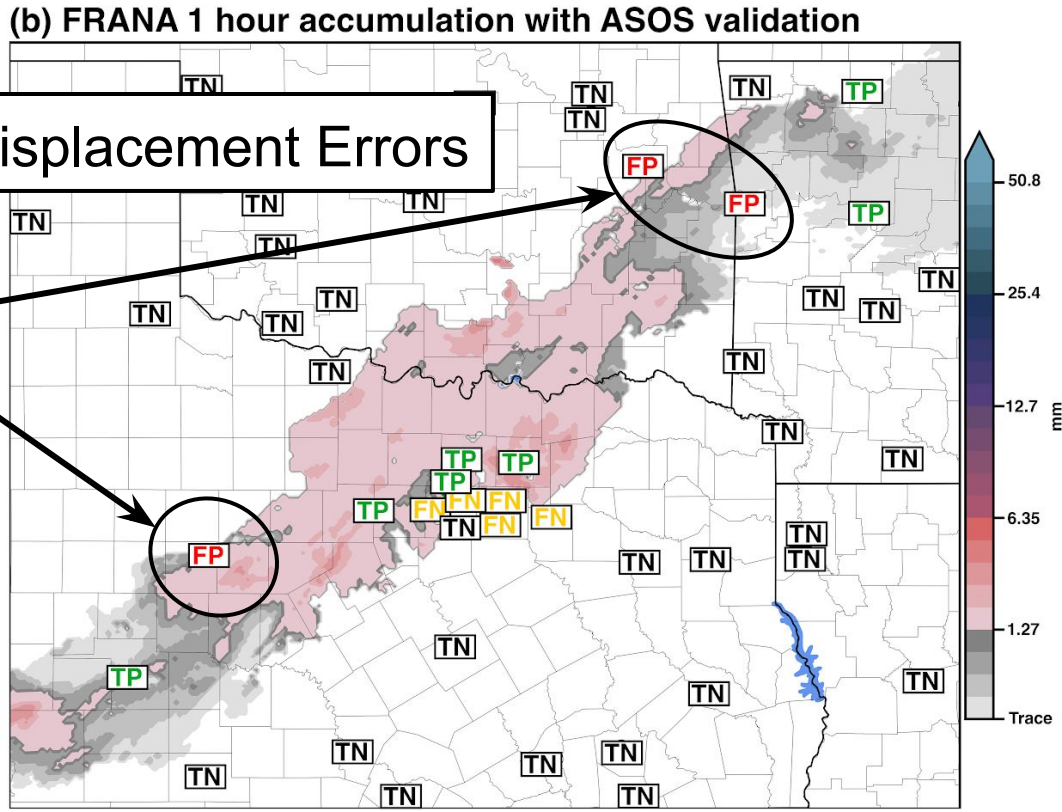


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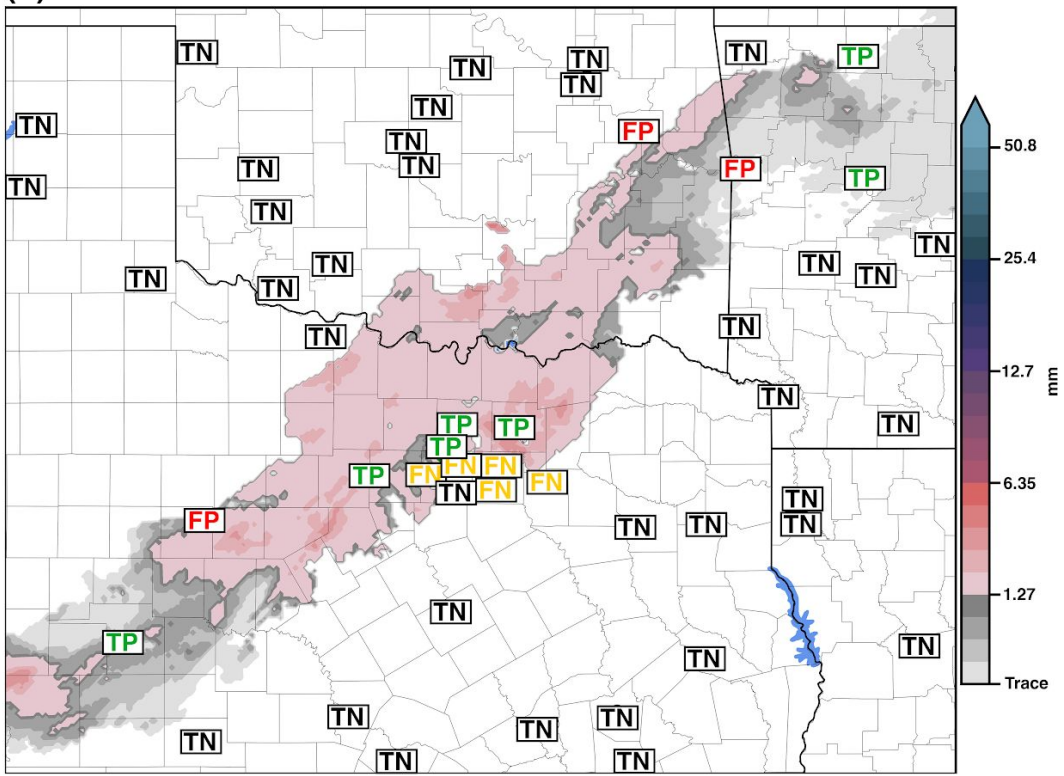
# Why is the FAR high? FRANA Footprint Errors Occur on Boundaries

**(b) FRANA 1 hour accumulation with ASOS validation**




| 1 winter season (2023-2024) | FAR |
|---|---|
| Strict Point Verification | 0.72 |

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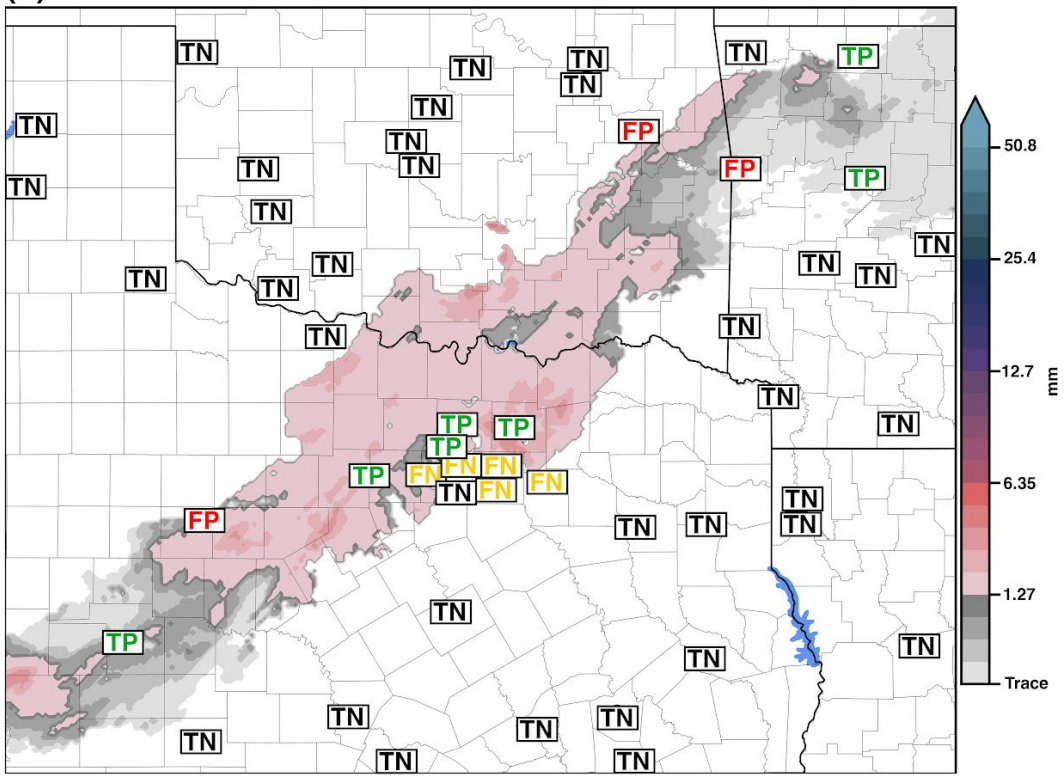


| 1 winter season (2023-2024) | FAR |
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| Neighborhood 15km | 0.30 |
| Neighborhood 30km | 0.09 |

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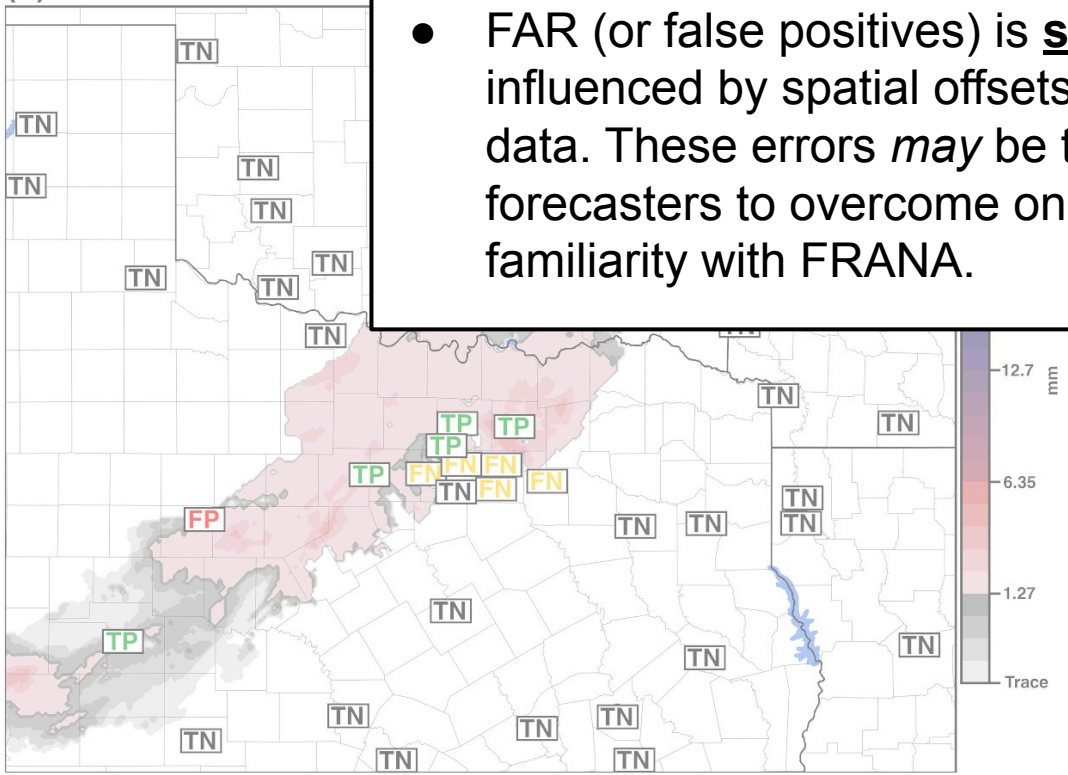
# Why is the FAR high? FRANA Footprint Errors Occur on Boundaries

(b) FRANA 1 hour accu[illegible] with ASOS validation




- FAR (or false positives) is **<u>strongly</u>** influenced by spatial offsets in the input data. These errors *may* be tolerable for forecasters to overcome once they gain familiarity with FRANA.

| | FAR |
|---|---|
| [illegible]ion | 0.72 |
| Neighborhood 15km | 0.30 |
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# What We Learned: How skillful is the FRANA footprint?

| 3 winter seasons (2020-2023) | POD | FAR | Bias | HSS |
|---|---|---|---|---|
| Accumulating ice only | 0.43 | 0.43 | 0.77 | 0.49 |
| Total footprint (including trace) | 0.44 | 0.64 | 1.23 | 0.39 |

**Q:** Why is the FAR high? What can be done to lower the FAR?

- Trace ice is overdone. Dewpoint depression rules will help.
- Spatial/temporal offsets in input data are causing the FAR to be high. Improvements to HRRR analysis and SBC are needed.

# What We Learned: How skillful is the FRANA footprint?

| 3 winter seasons (2020-2023) | POD | FAR | Bias | HSS |
|---|---|---|---|---|
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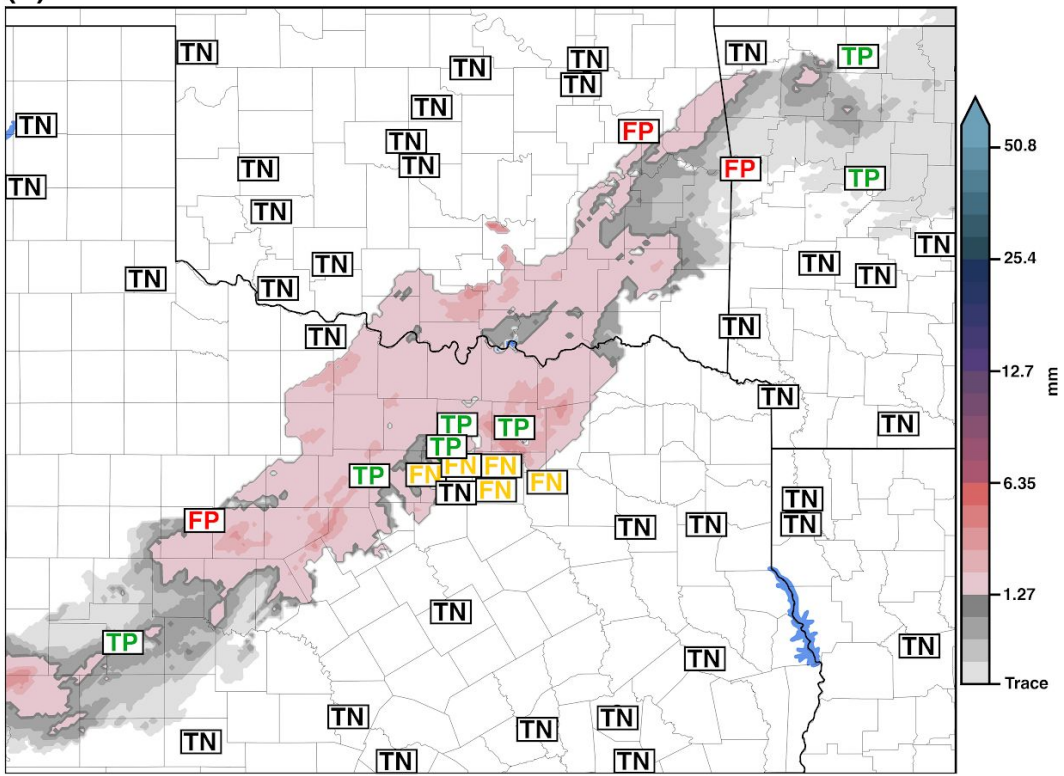
**Q:** Why is the POD low and what can be done to raise it?

# Why is the POD low? FRANA Footprint Errors Occur on Boundaries

**(b) FRANA 1 hour accumulation with ASOS validation**

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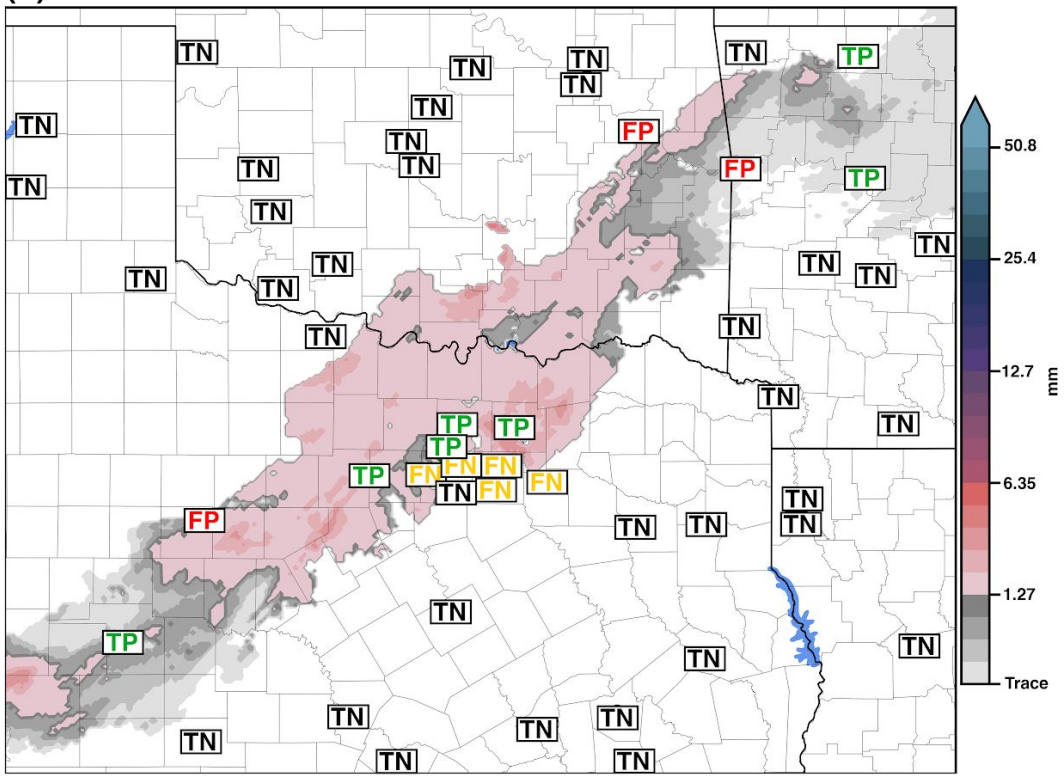


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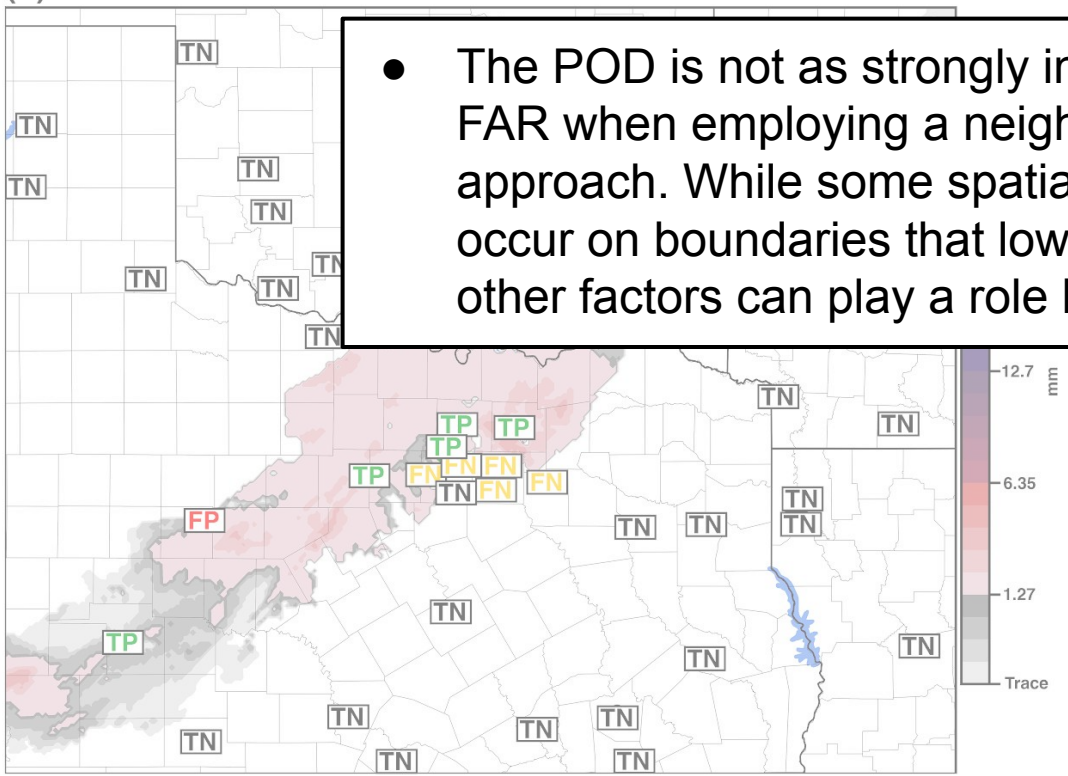


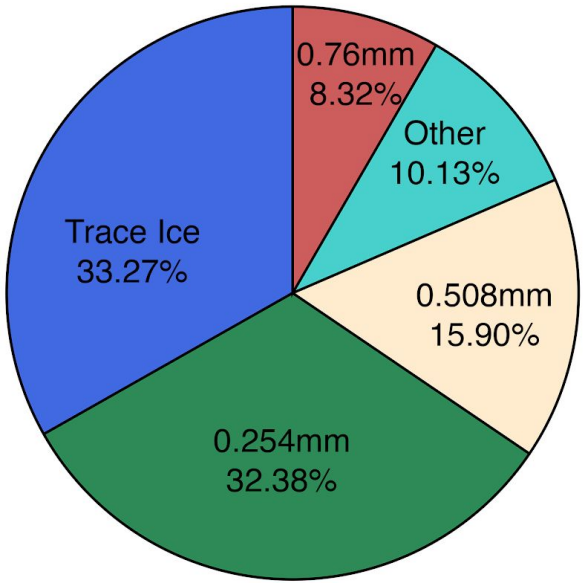

- The POD is not as strongly influenced as the FAR when employing a neighborhood approach. While some spatial/temporal errors occur on boundaries that lower the POD, other factors can play a role here.

| | POD |
|---|---|
| on | 0.39 |
| Neighborhood 15km | 0.54 |
| Neighborhood 30km | 0.61 |

TP = True Positive, TN = True Negative, FP = False Positive, FN = False Negative

# Why is the POD low?

## (a) Goodrich Ice



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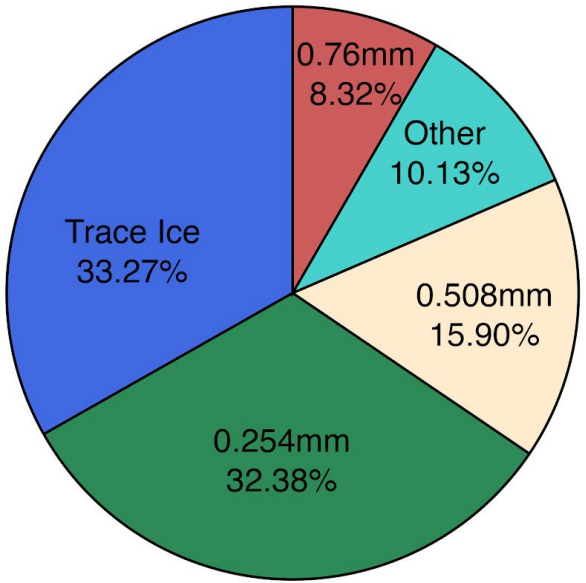


⅔ of the time that FRANA fails to produce ice, Goodrich measures a trace or 0.01 inches

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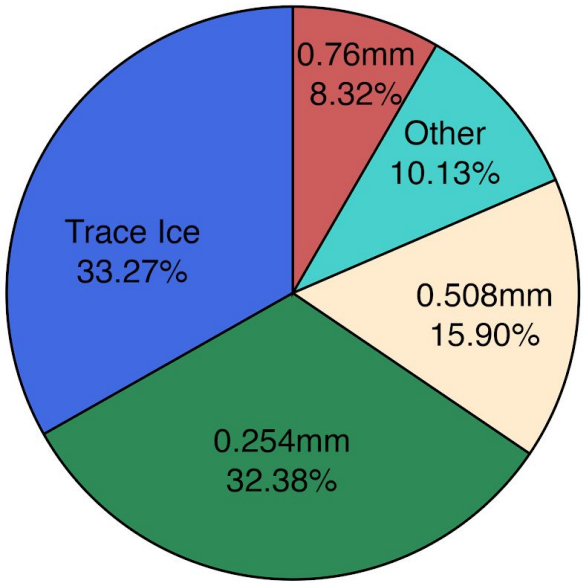


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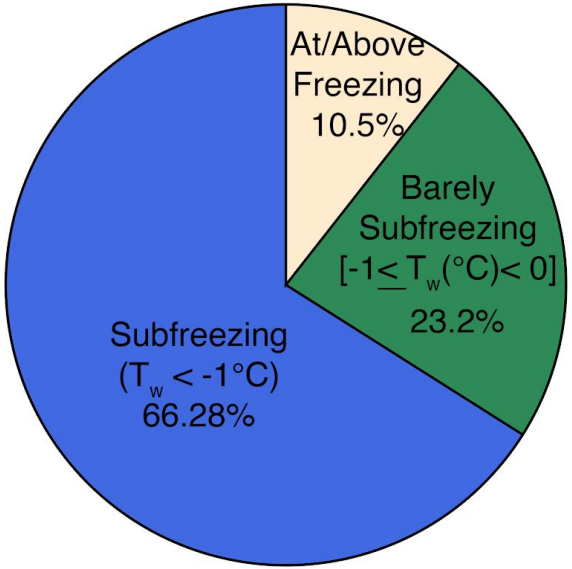
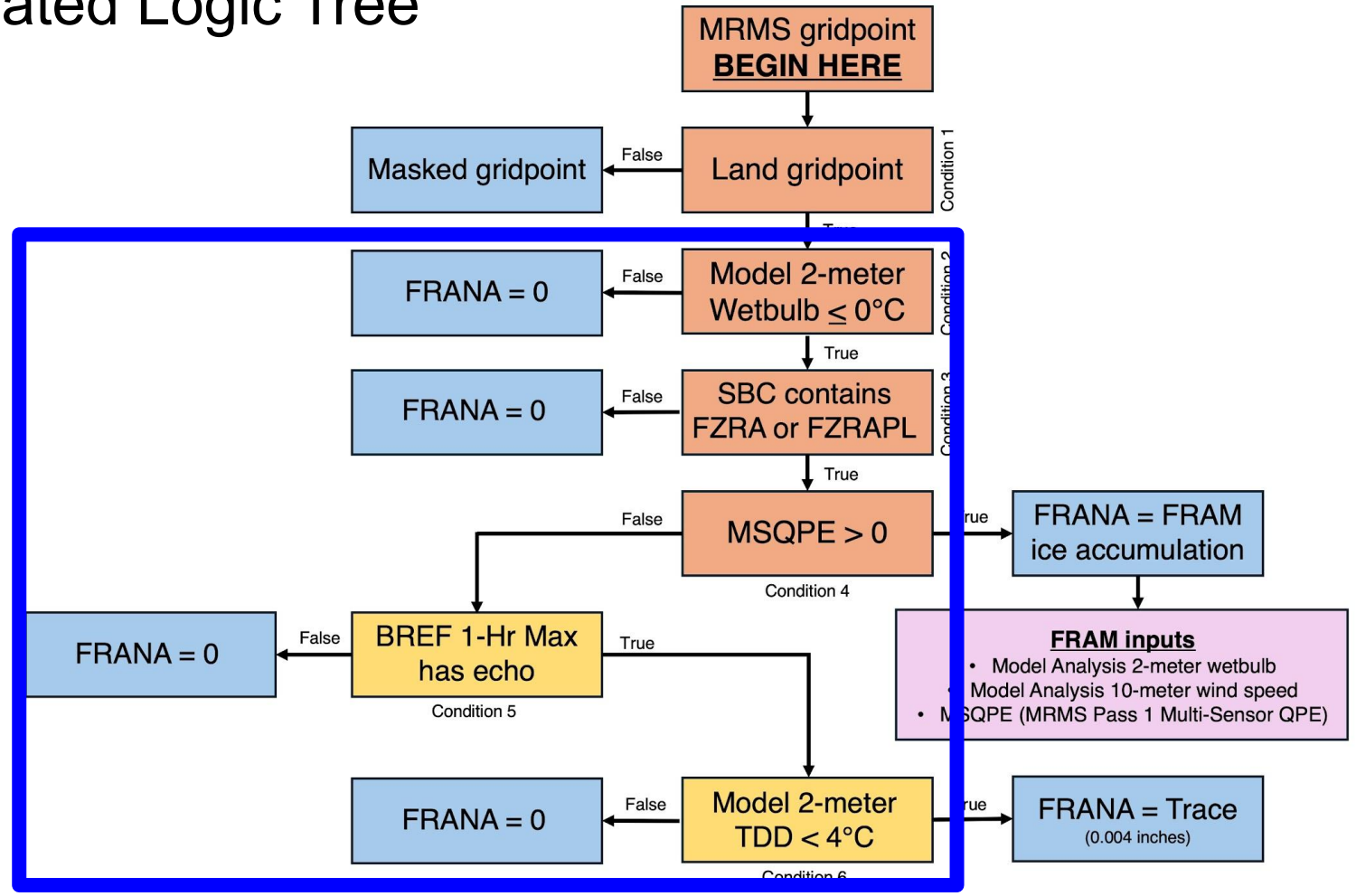
## (b) ASOS Wetbulb




Most of these cases are cold. But ⅓ of these cases have a 2-m wetbulb near 0°C

# Updated Logic Tree



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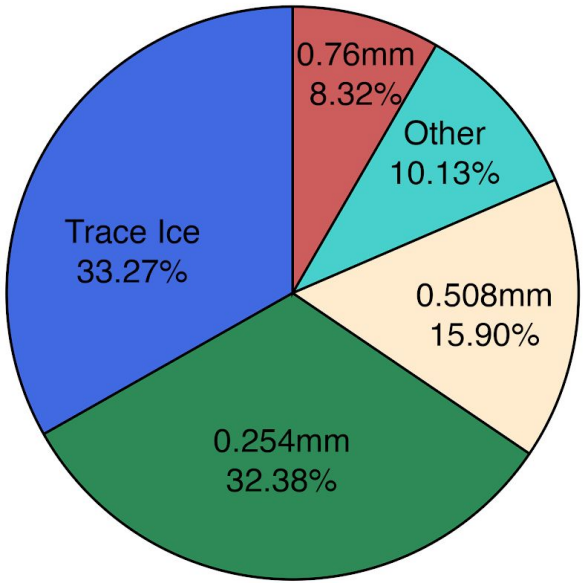


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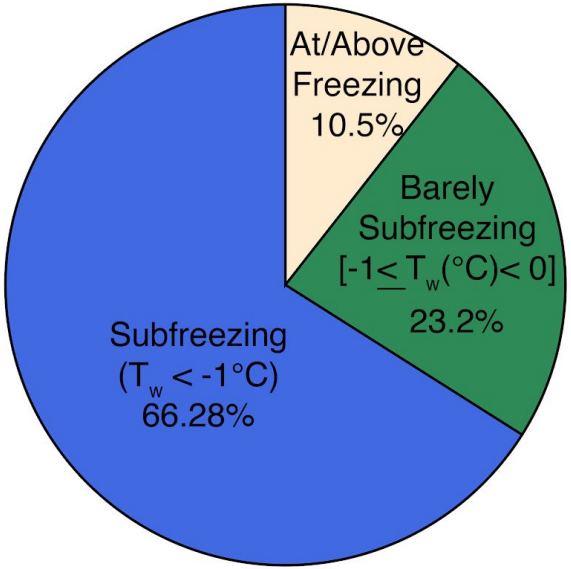


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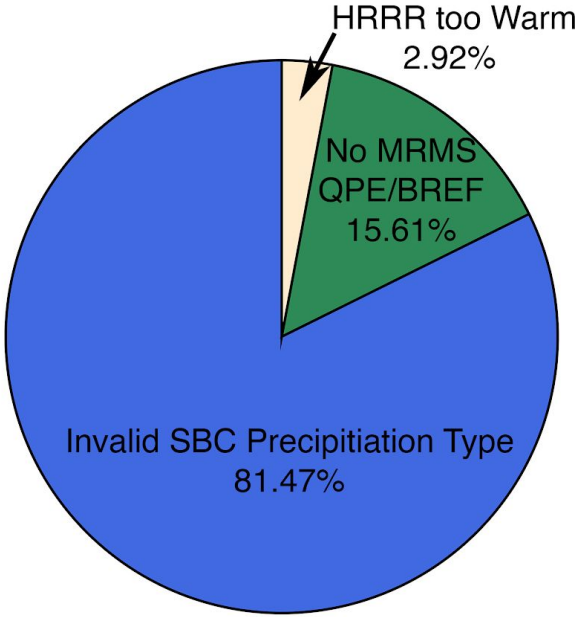
## (c) Sources of Failure



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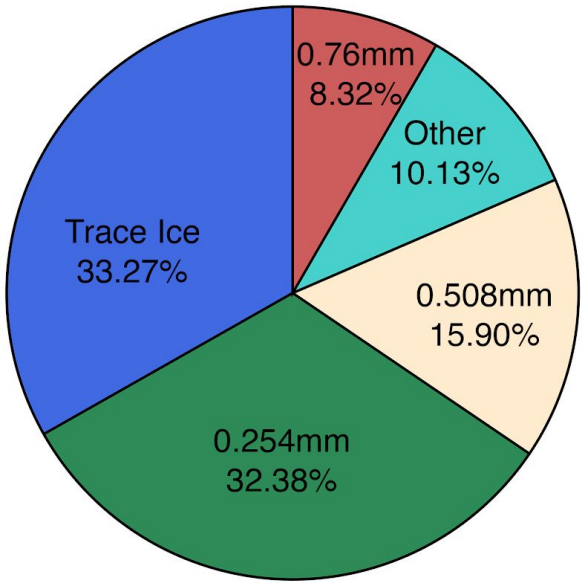


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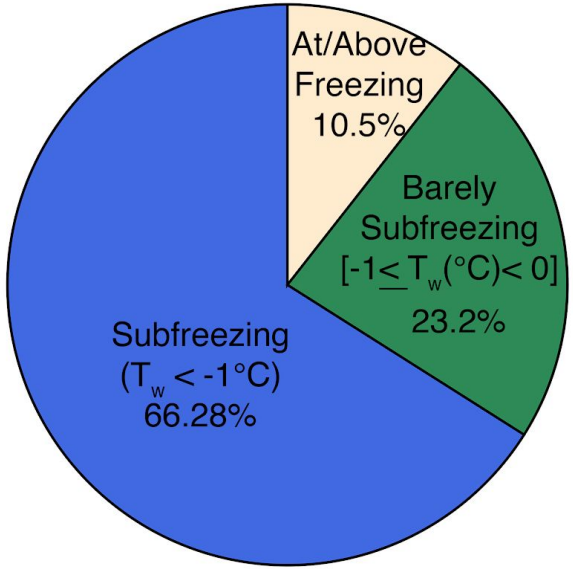


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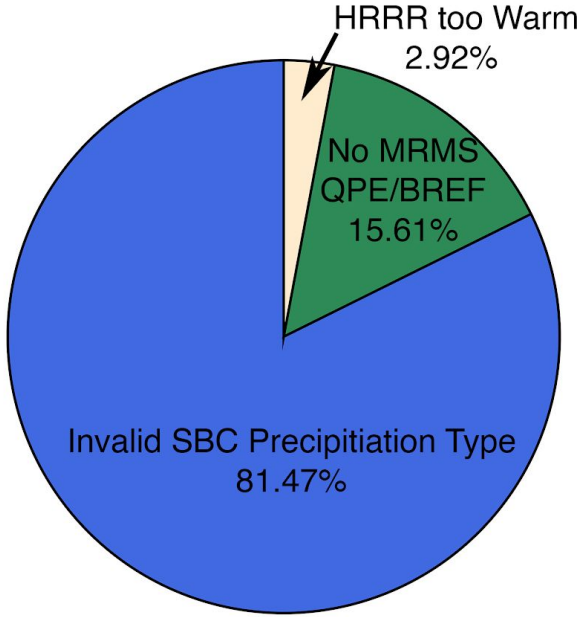
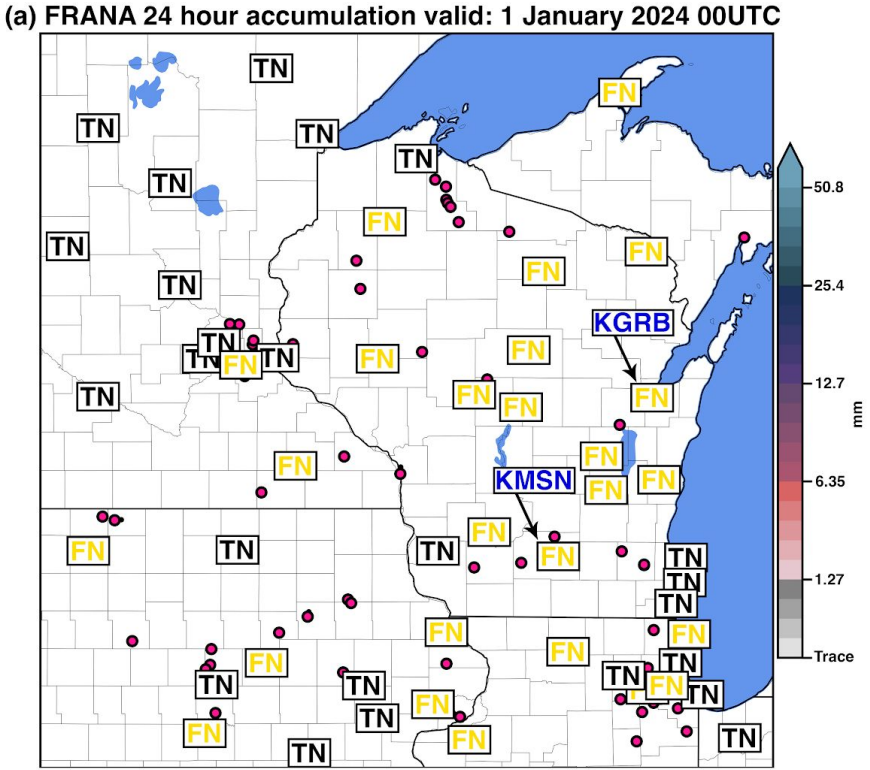



Is this due to the ptypes being too cold or warm? SBC is diagnosing snow for most of these.

# Why is the POD low? FRANA struggles in FZDZ due to ptype diagnoses

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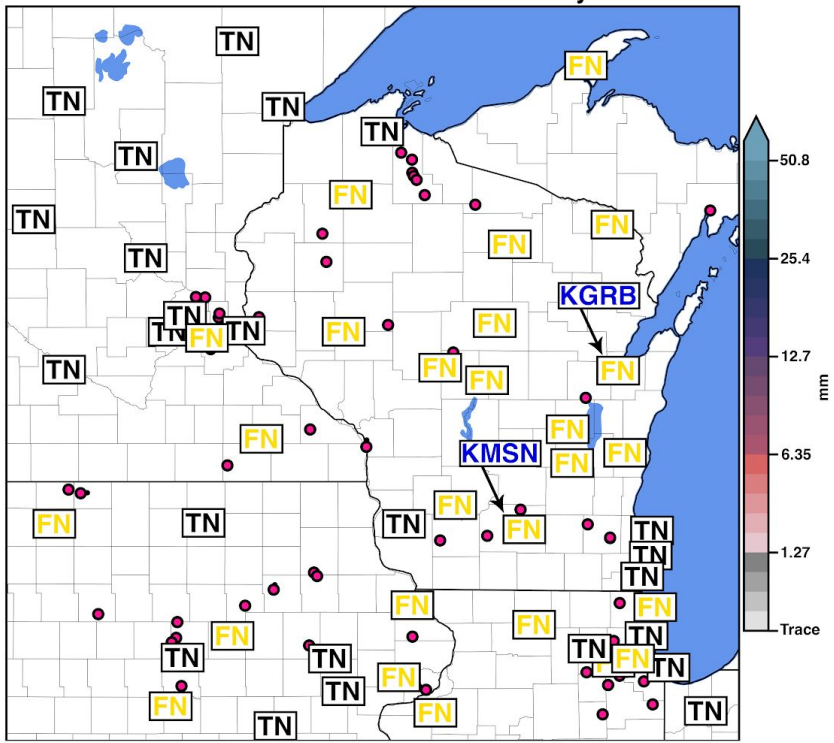
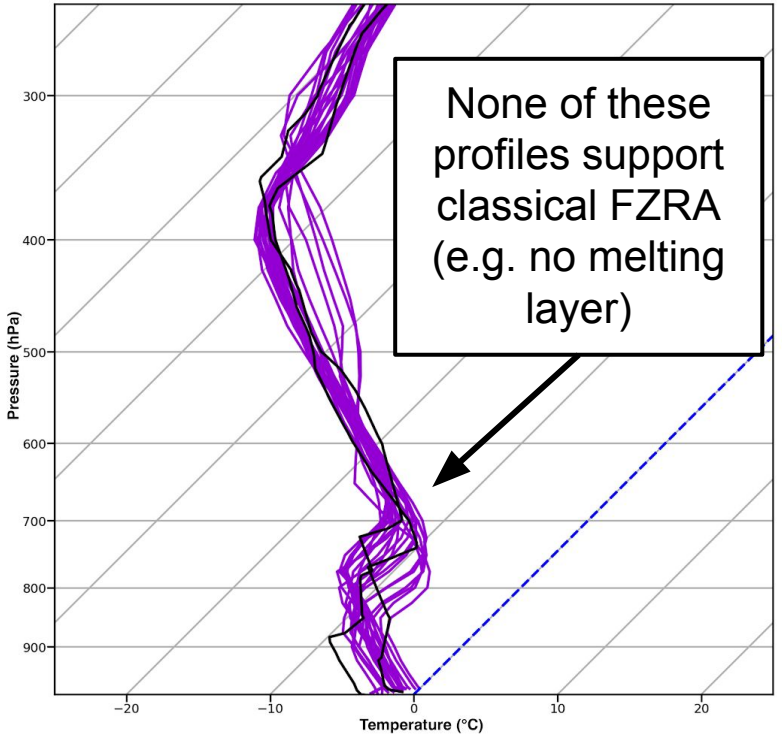
(a) FRANA 24 hour accumulation valid: 1 January 2024 00UTC




(b) Wetbulb profiles: KMSN HRRR (purple); KGRB observed (black)

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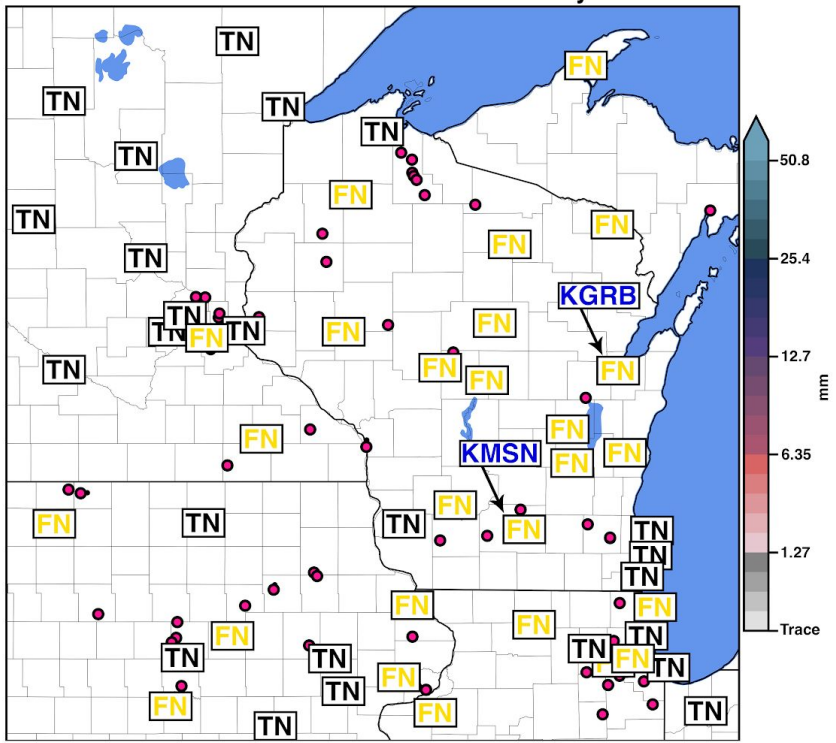


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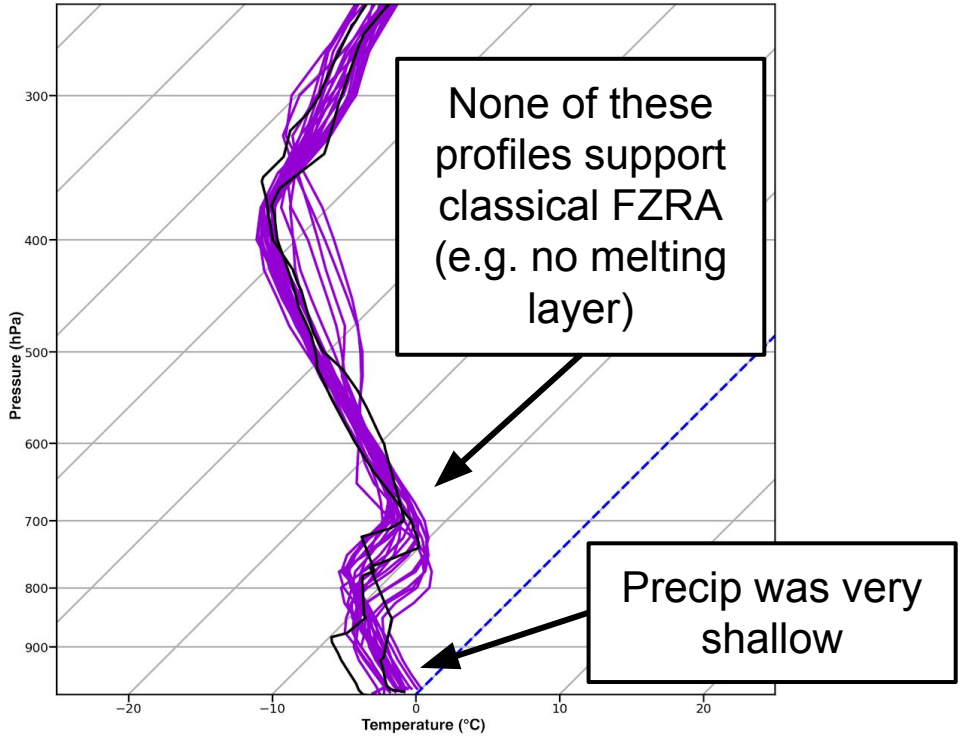


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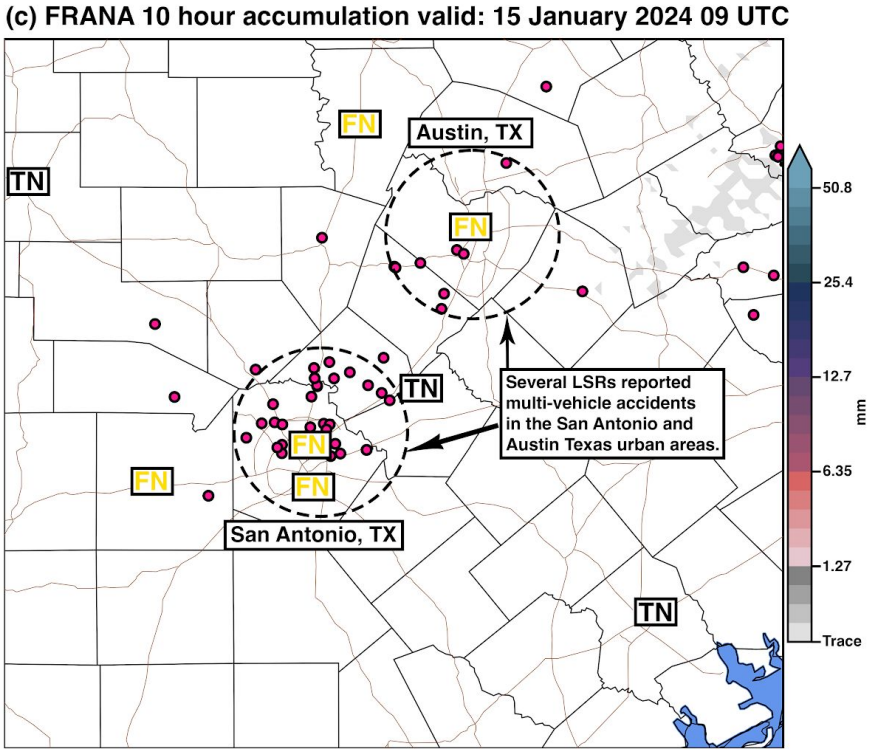
*The SBC struggles to distinguish between snow and FZDZ in subfreezing profiles*

# Why is the POD low? FRANA struggles when radar can’t detect FZDZ

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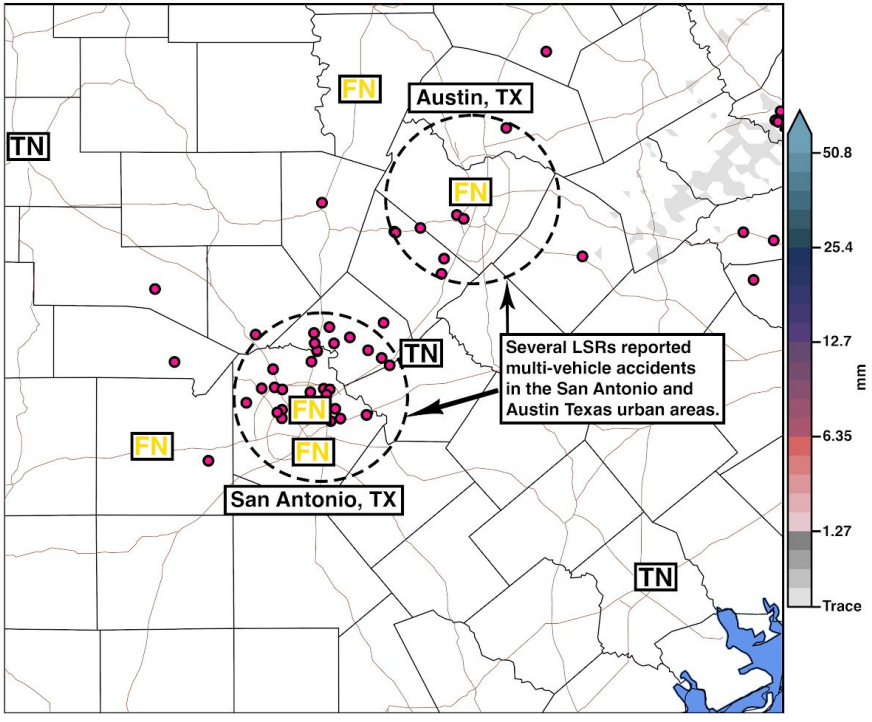
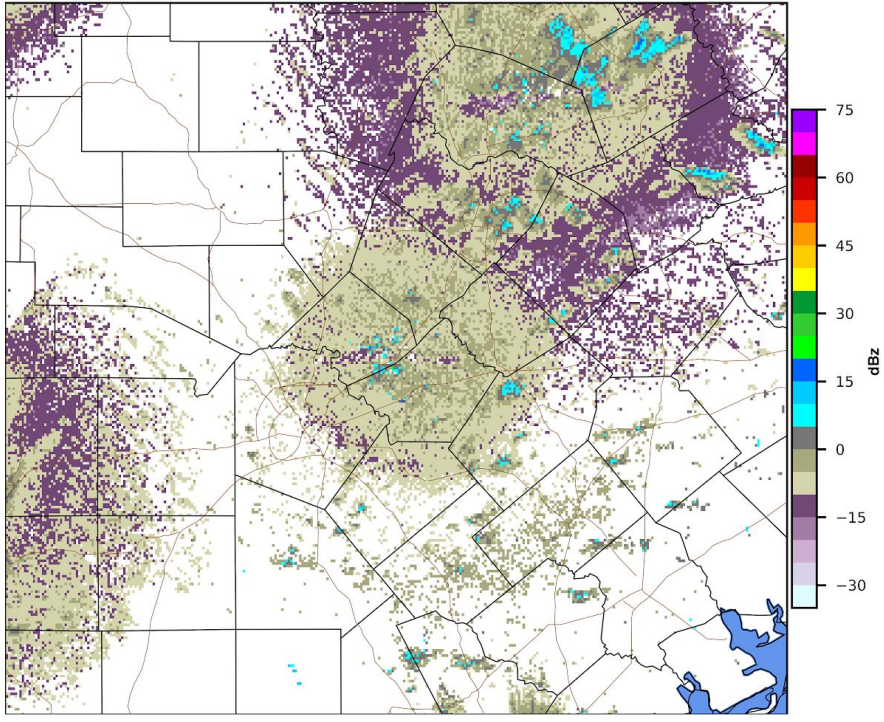
# Why is the POD low? FRANA struggles when radar can't detect FZDZ

(c) FRANA 10 hour accumulation valid: 15 January 2024 09 UTC




(d) Base Reflectivty (no QC) valid: 15 January 2024 09 UTC

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*MRMS radar quality control sometimes removes FZDZ. Radar overshooting also causes FZDZ to be missed.*

# What We Learned: How skillful is the FRANA footprint?

| 3 winter seasons (2020-2023) | POD | FAR | Bias | HSS |
|---|---|---|---|---|
| Accumulating ice only | 0.43 | 0.43 | 0.77 | 0.49 |
| Total footprint (including trace) | 0.44 | 0.64 | 1.23 | 0.39 |

**Q:** Why is the POD low and what can be done to raise it?

- Spatial/temporal errors in the input data are part of the problem
- Distinguishing snow from non-classical freezing rain/drizzle is the major problem
- Radar overshooting
- Improvements are needed to MRMS quality control in winter

# Forecaster recommendations for nowcasting ice using FRANA

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  - When FRANA overestimates/underestimates the footprint with *accumulating ice* (e.g. not trace), these errors are more likely to be closer to the true footprint and suffer from spatial/temporal error in the input data.

*Example events on previous slides*

# Journal Article

**Creation and Evaluation of the Freezing Rain Accumulation National Analysis (FRANA) in Preparation for NWS Operations**

Daniel D. Tripp,[a,b] Adam D. Werkema,[a,b] Heather D. Reeves,[a,b] Brian L. Barjenbruch,[c] Kristopher J. Sanders,[d]

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**Anticipating it to be in early online release soon*

## What did we learn about FRANA?

*(Highlights from the paper)*

- **How skillful is the footprint (spatial coverage) of FRANA?** ✓
- **How skillful are the FRANA accumulations?**

# What We Learned: How skillful are the FRANA accumulations?


**How skillful is FRAM which runs inside of FRANA?**

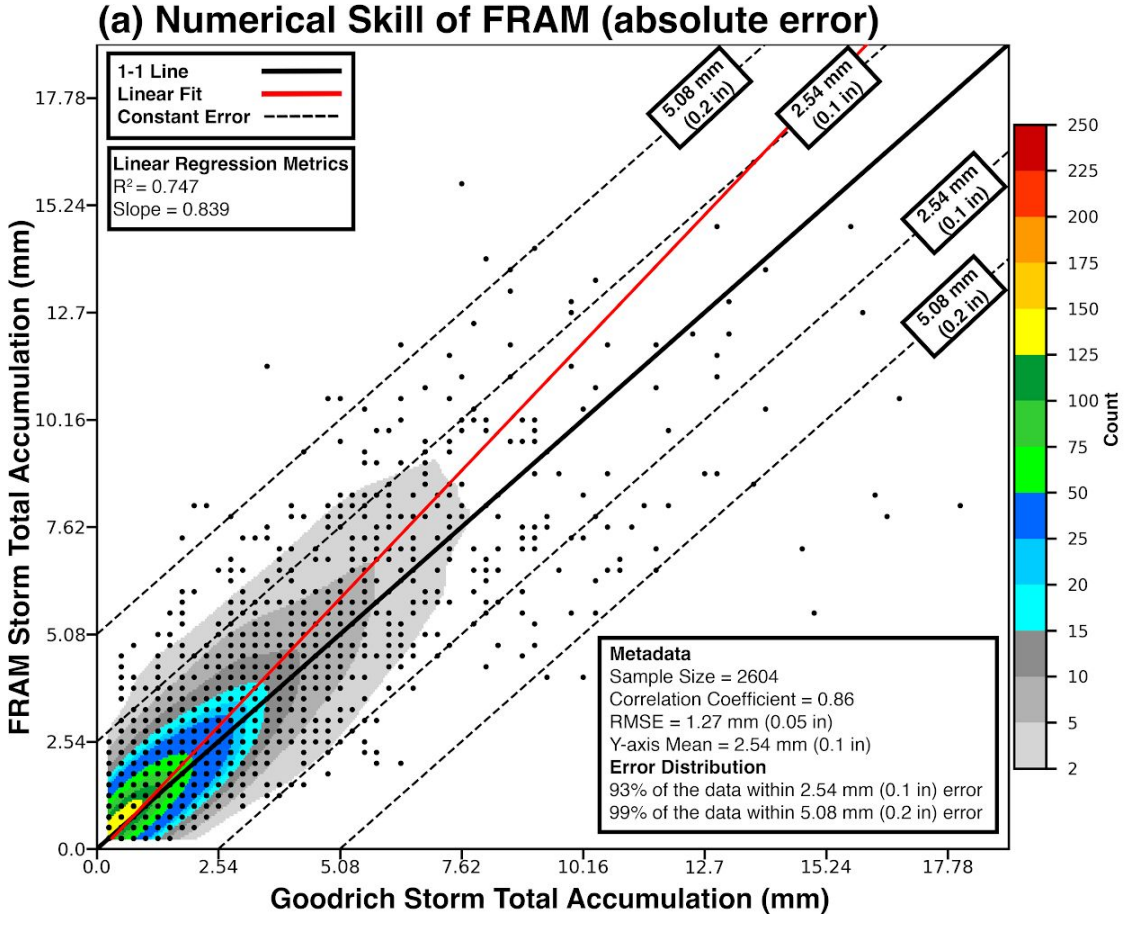
- We ran an experiment to benchmark FRAM on “ground truth” data

# What We Learned: How skillful are the FRANA accumulations?


**How skillful is FRAM which runs inside of FRANA?**

- We ran an experiment to benchmark FRAM on “ground truth” data
- This experiment runs FRAM as though it were part of the ASOS system receiving inputs from all of these sensors.

# How skillful is FRAM which runs inside of FRANA?




## “Ground Truth” Experiment

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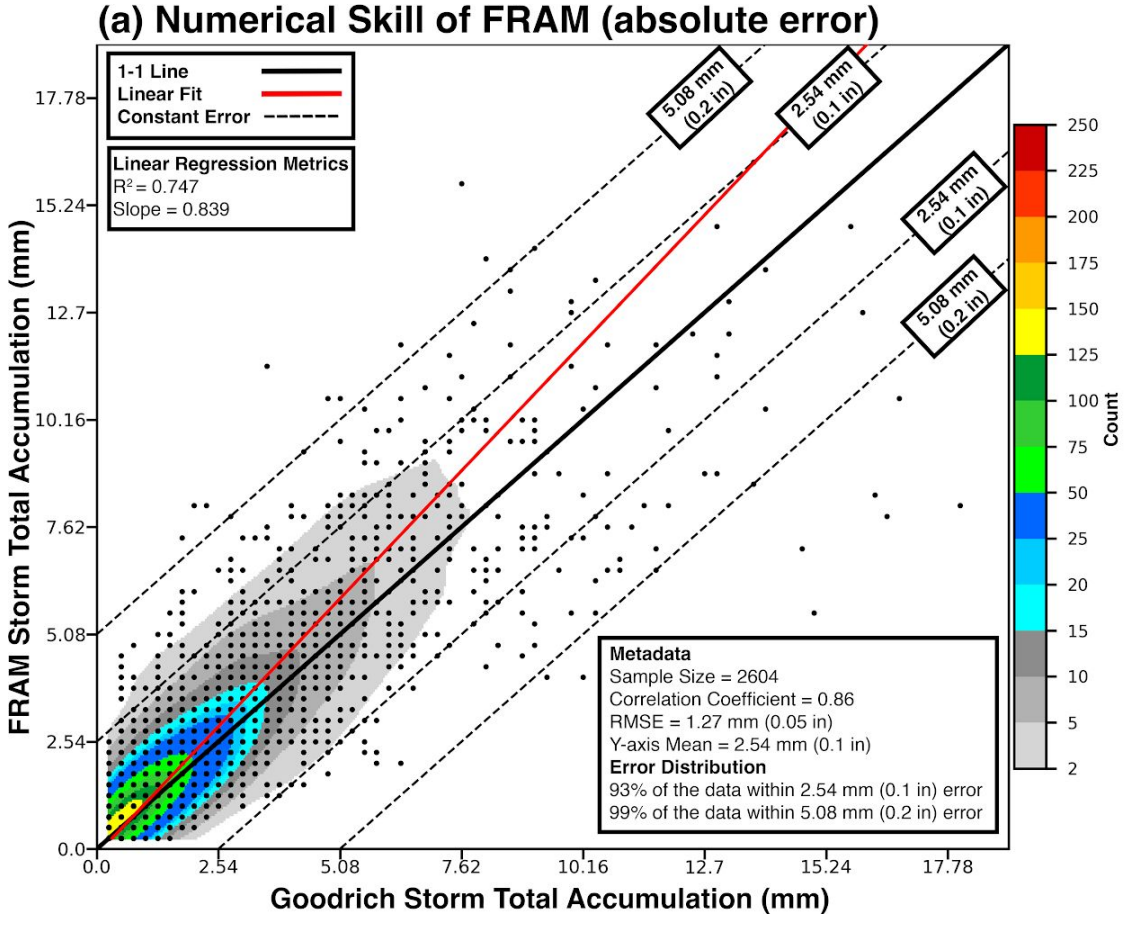


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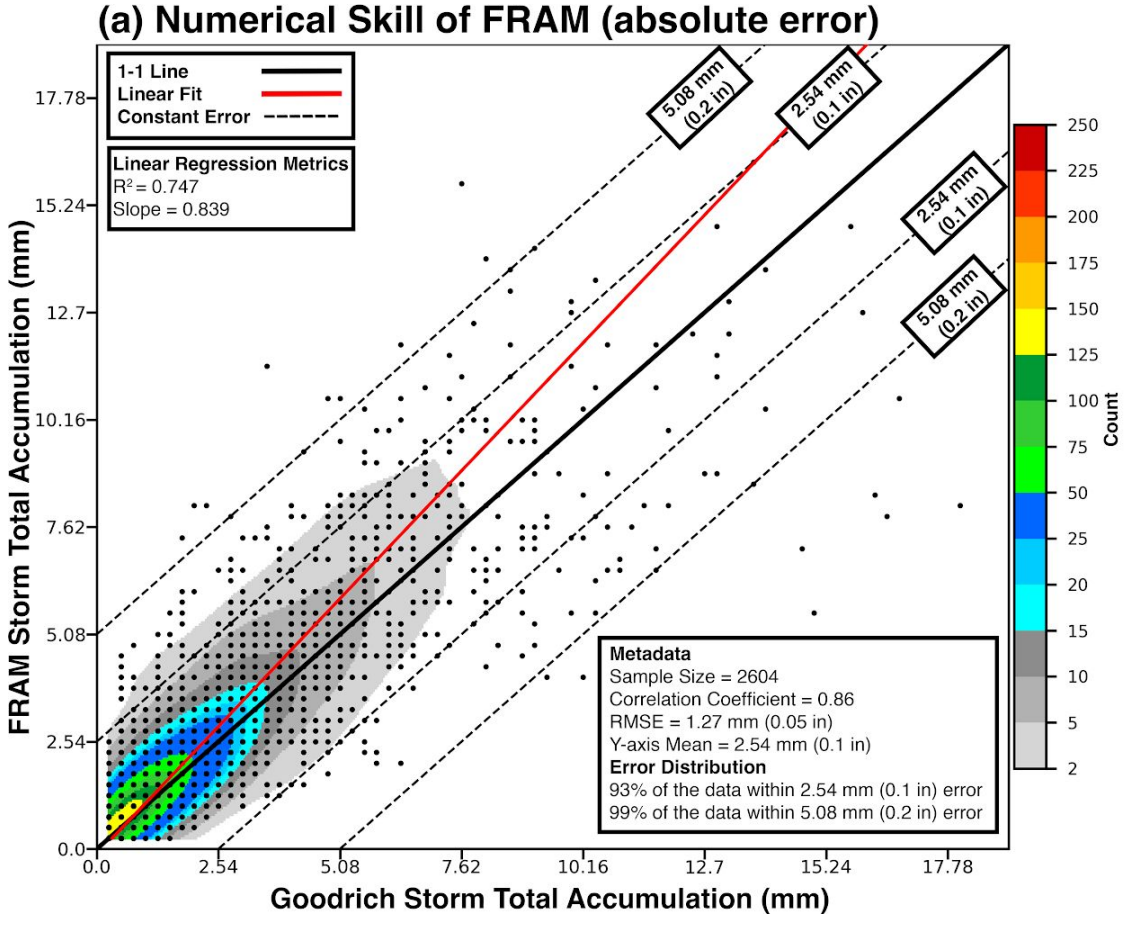


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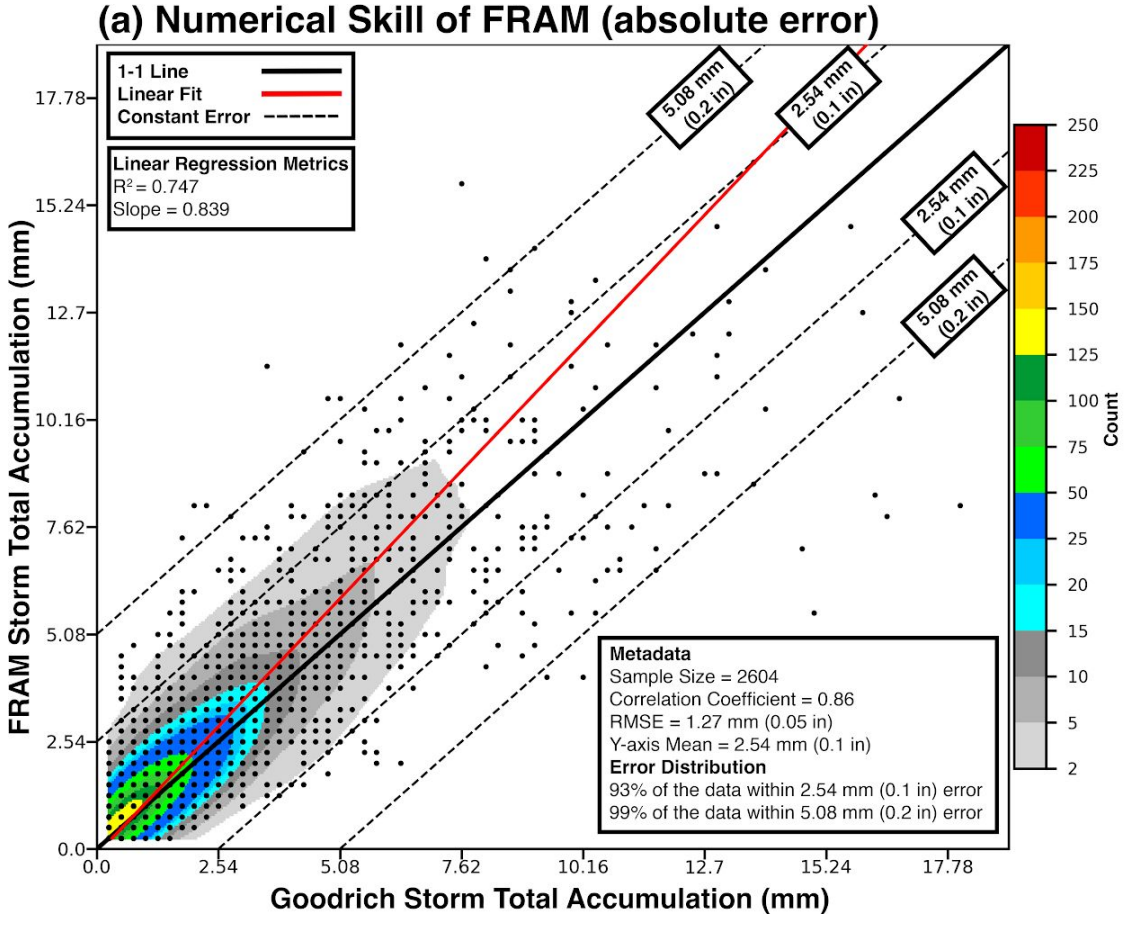


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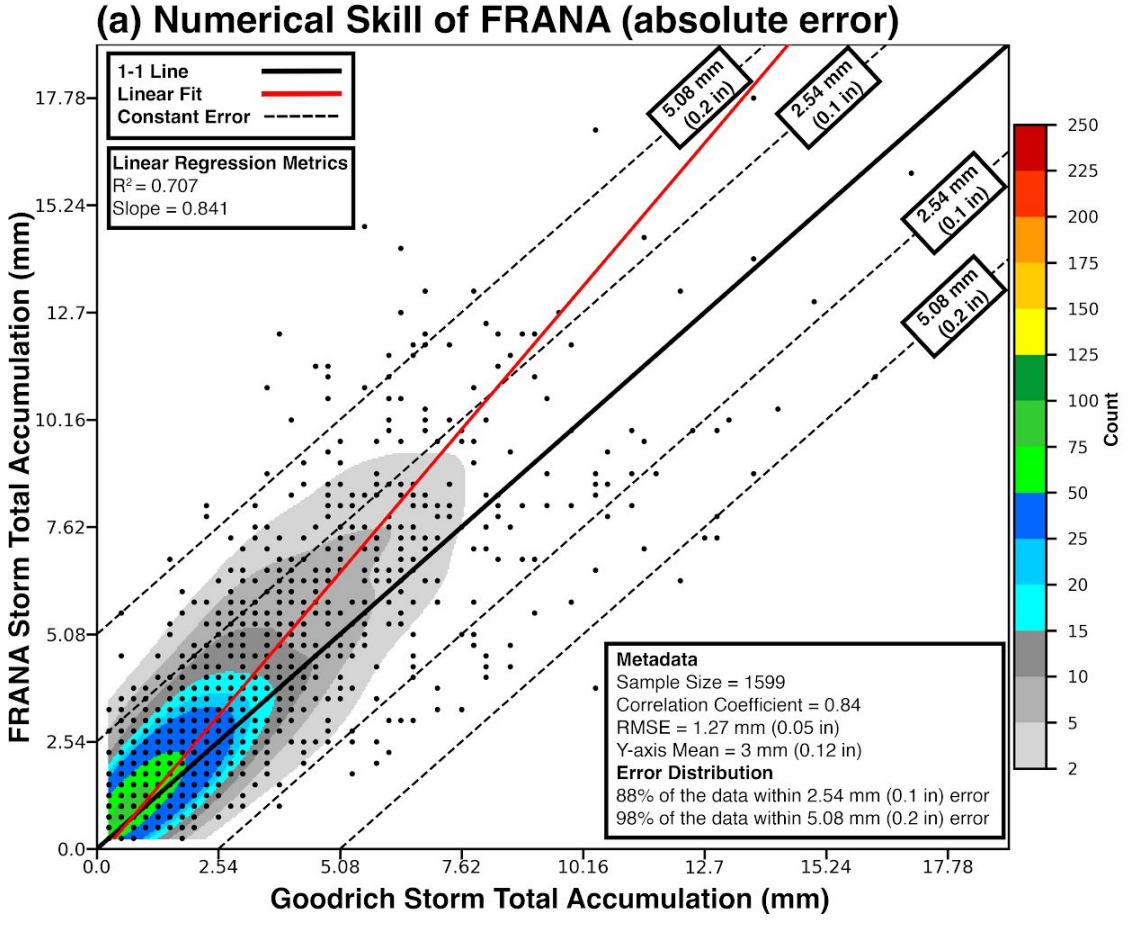
*Now switching to FRANA… how much does the skill degrade when MRMS inputs are fed to FRAM?*

# What We Learned: How skillful are the FRANA accumulations?




## FRANA skill

*(using FRAM)*

- RMSE is unchanged
- The high bias from FRAM is not drastically increased using MRMS inputs
- 88% of the data (events) have errors less than 0.1 inches

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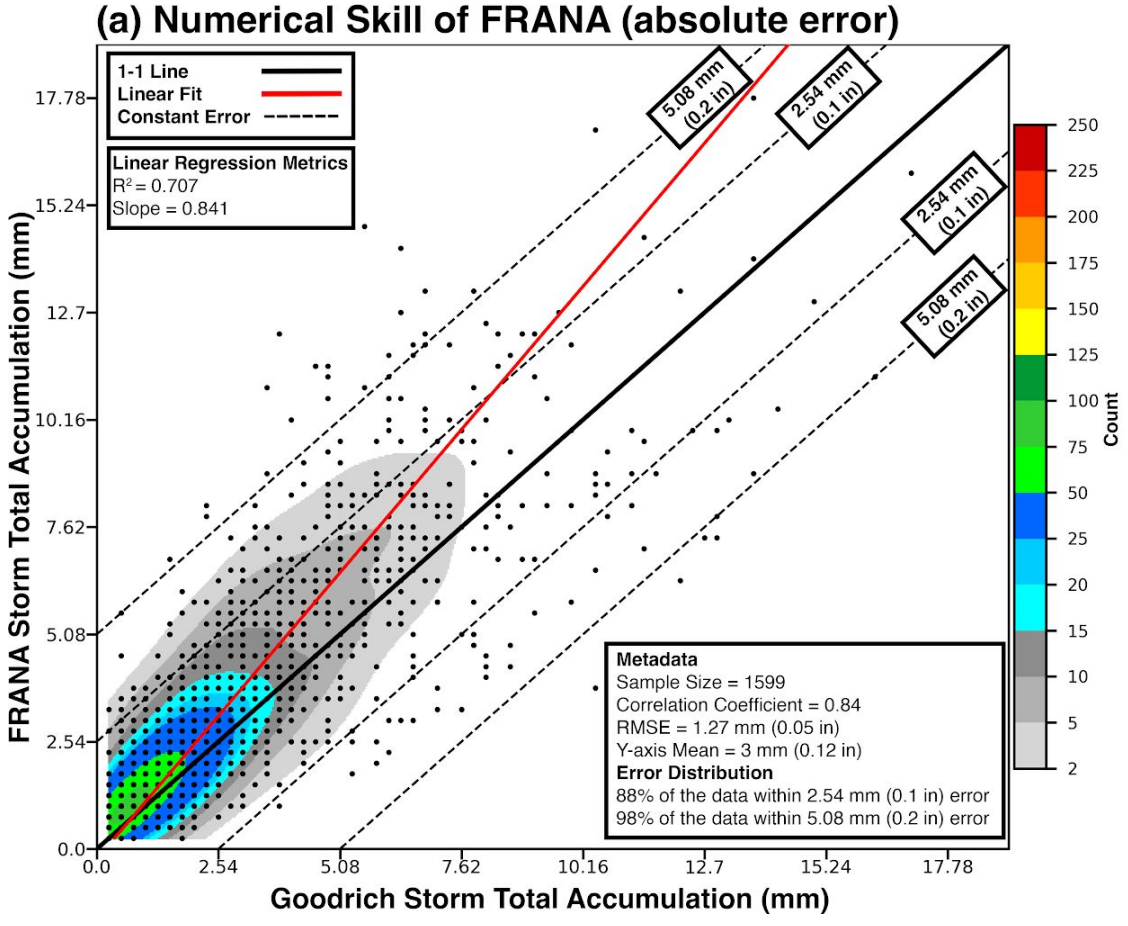


## FRANA skill

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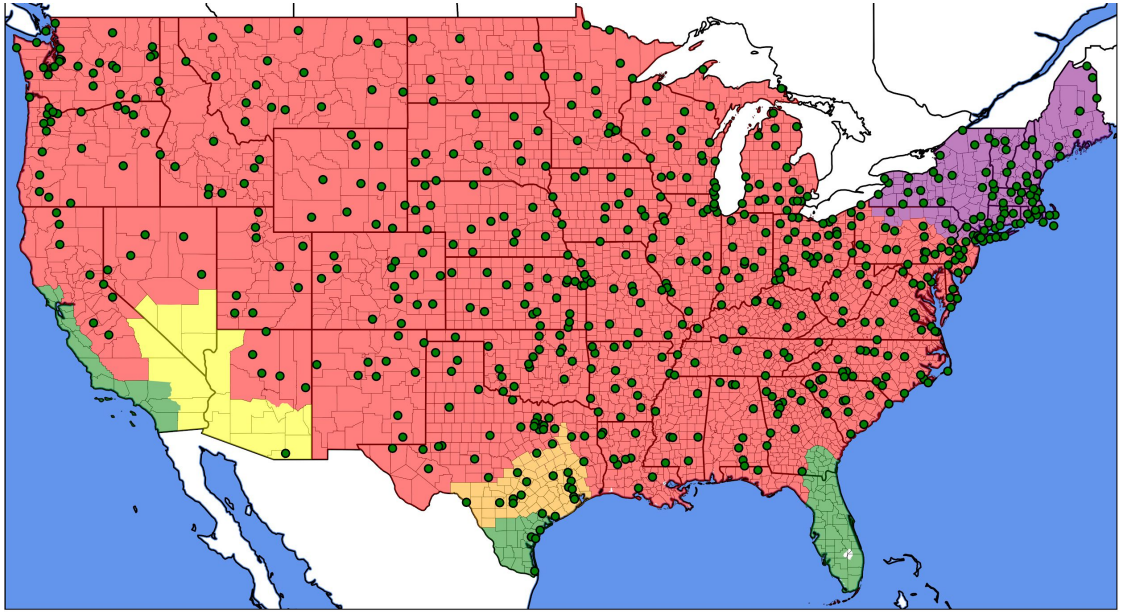
*FRAM is the primary source of the high bias in FRANA. Other sources of error come from radar bright-banding and artifacts*

# What do these accumulation errors mean for forecasters?



Green dots = Goodrich sensors

**Ice accumulation criteria for a NWS warning**

| 0.25 mm (0.01 in) | 2.54 mm (0.10 in) | 3.05 mm (0.12 in) | 6.35 mm (0.25 in) | 12.7 mm (0.50 in) |
|---|---|---|---|---|

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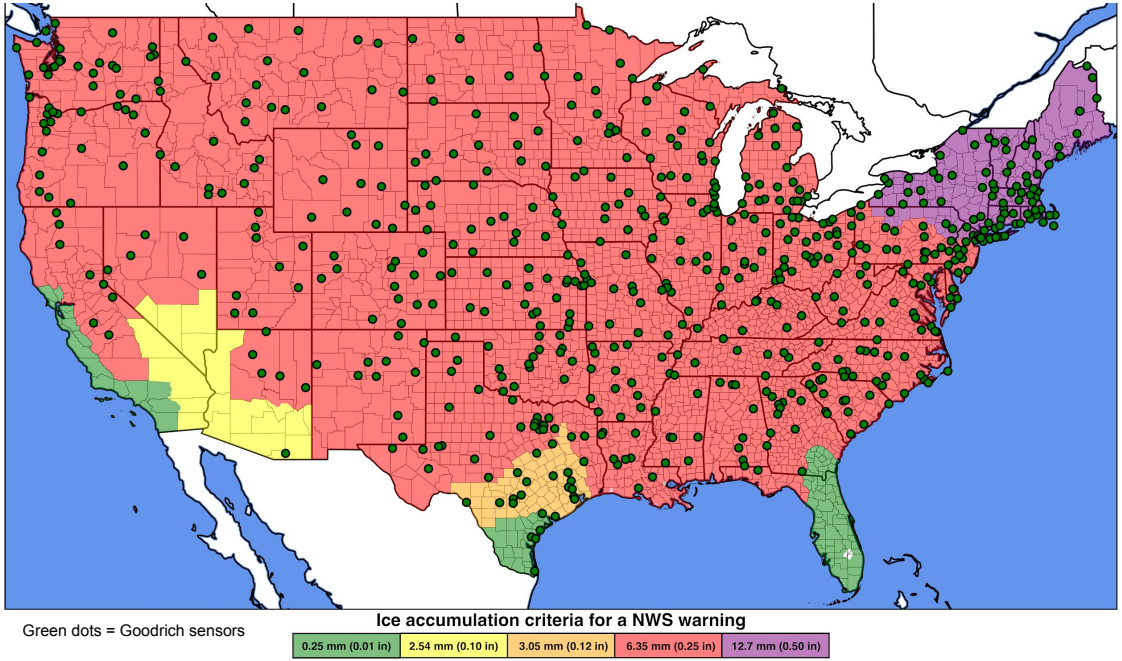


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## Nowcasting Applications

- Forecasters: Let us know what you think!
- Live verification maps have been created where forecasters can benchmark the accumulations of FRANA against ASOS and LSRs. Link to maps

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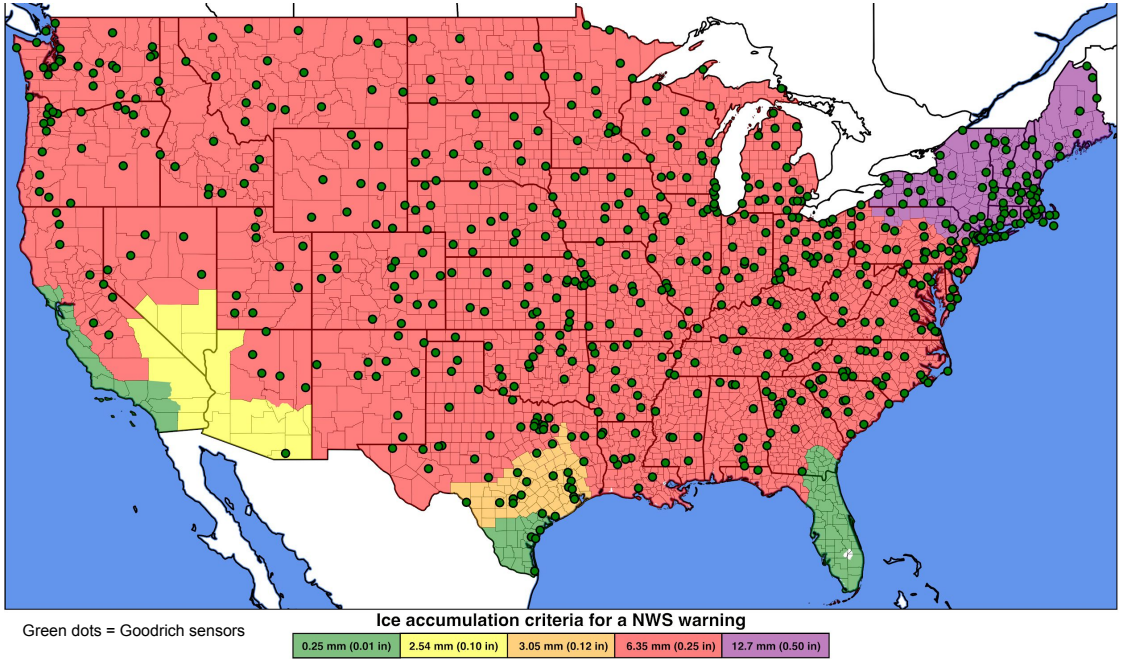


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## Analysis-of-Record

- The research team is seeking funding to improve the accuracy of FRANA so it can be more robust for research/forecasting purposes.

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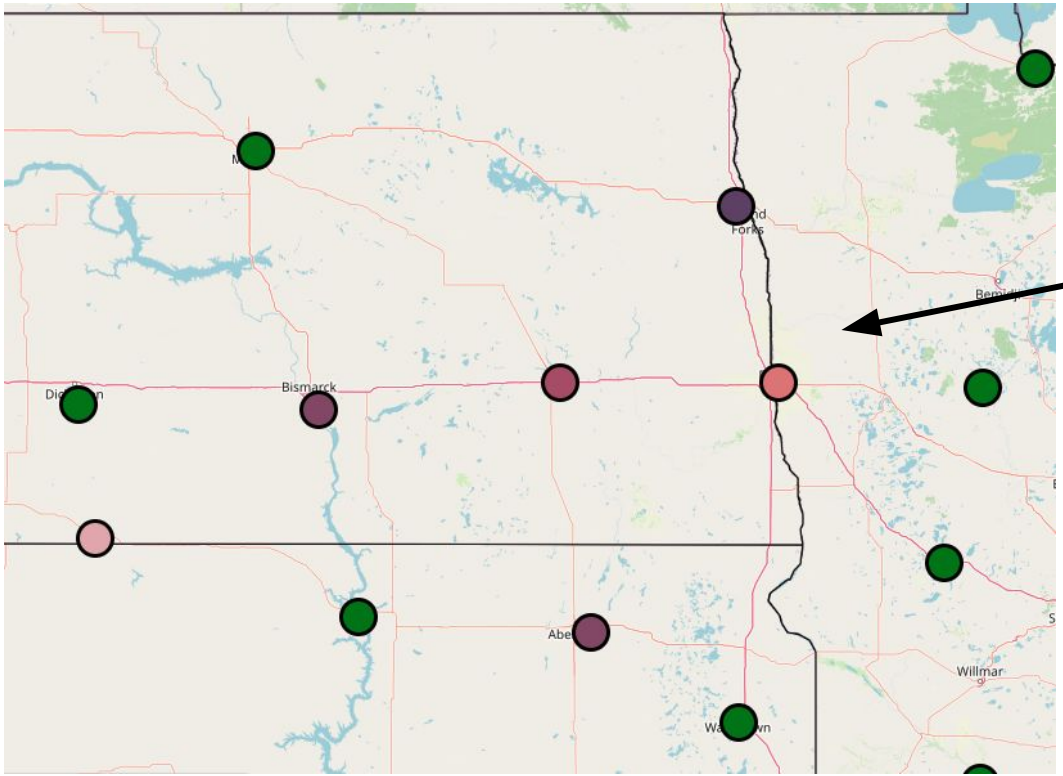
I've shown you how to interpret FRANA and problems to look out for… now let's talk about the success stories

# What We Learned: FRANA Also Has Successes




If you didn't have FRANA, this is what you could see for a large ice storm that hit ND/SD.

Overestimate, Underestimate, TN = True Negative, FP = False Positive

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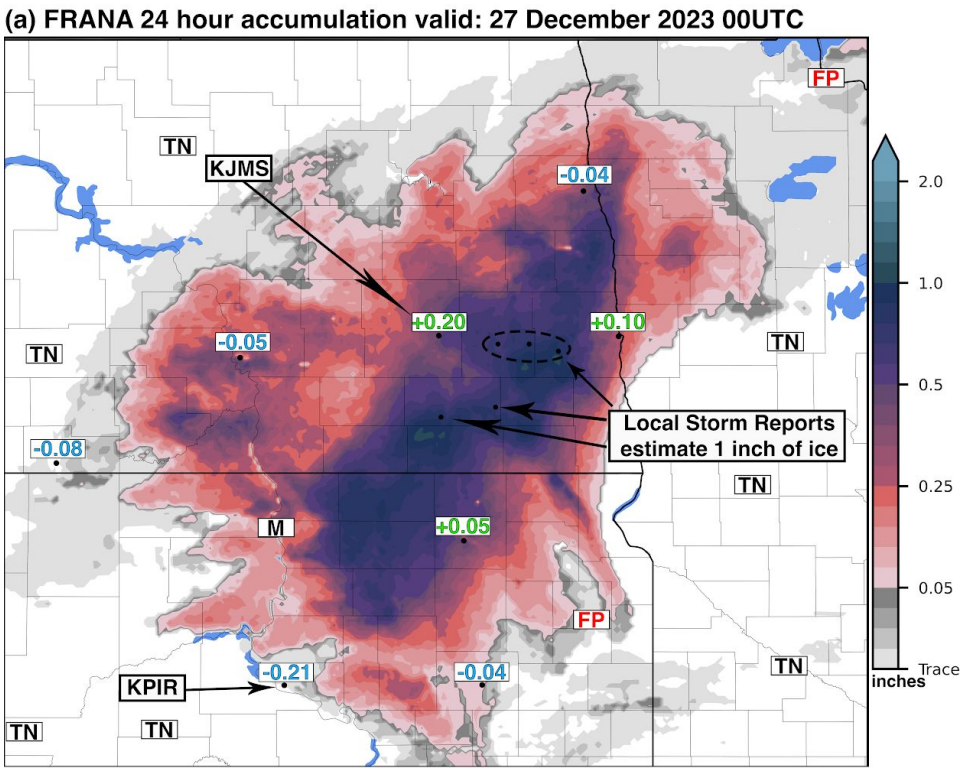


## December 27, 2023

- Large event where accumulations reached 1 inch.
- Fairly good agreement on the accumulations and the footprint. Larger accumulations typically come with larger errors.

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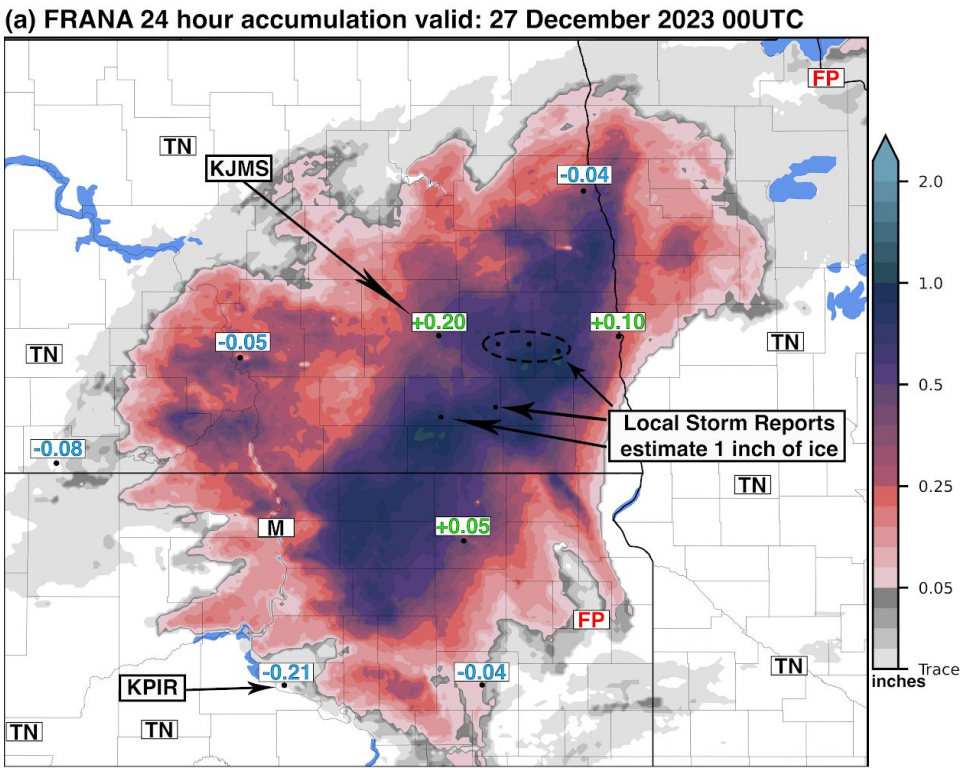


## December 27, 2023

- Large event where accumulations reached 1 inch.
- Fairly good agreement on the accumulations and the footprint. Larger accumulations typically come with larger errors.
- 2 stations (KJMS and KPIR) had larger errors, but using a 20km neighborhood would result in a perfect prediction.

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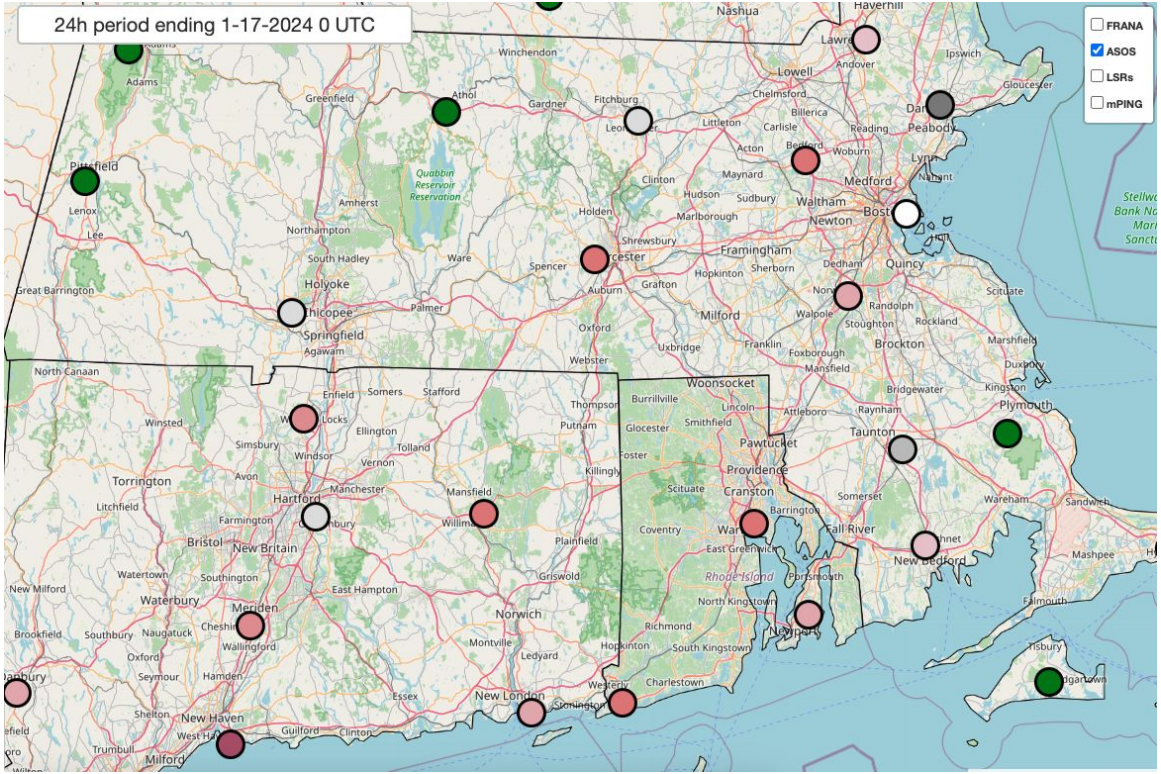


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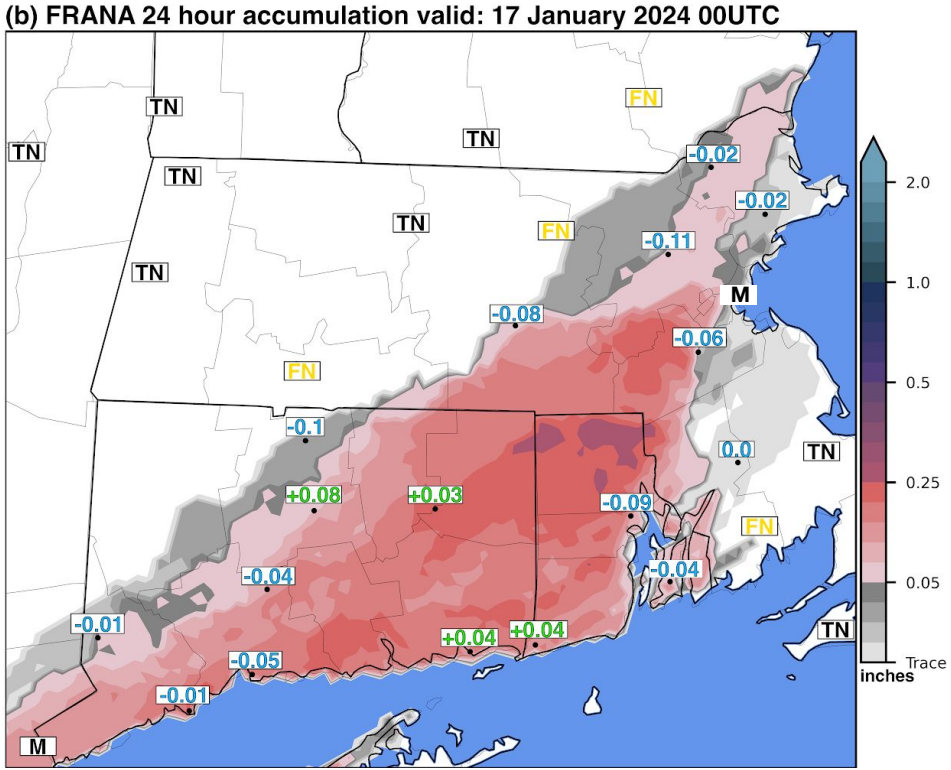
# What We Learned: FRANA Also Has Successes

## January 17, 2024

- Lower magnitude event where accumulation errors were also lower in magnitude.
- Good agreement on the accumulations and the footprint.
- The northwest edge of the footprint missed 3 stations that recorded trace ice.
- 1 other station to the southeast was missed by 2 km



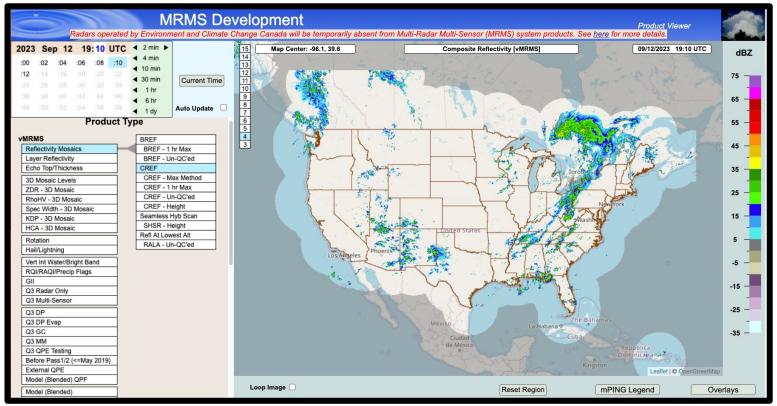

Overestimate, Underestimate, TN = True Negative, FP = False Positive, FN = False Negative

# How can I access FRANA this winter?

## vMRMS Web Viewer

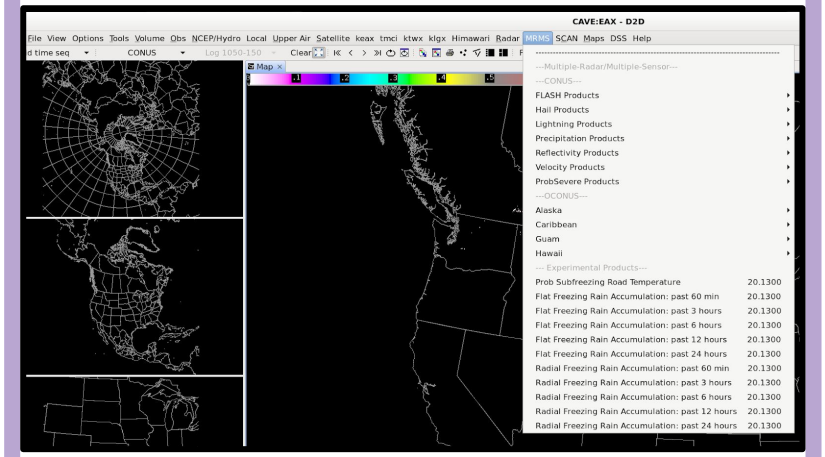
***(noaa.gov IP address only)***

This is an experimental MRMS viewer hosted by NSSL. The product can be found under the tab “FRANA”. Link: https://mrms-dev.nssl.noaa.gov/qvs/vmrms/viewer/

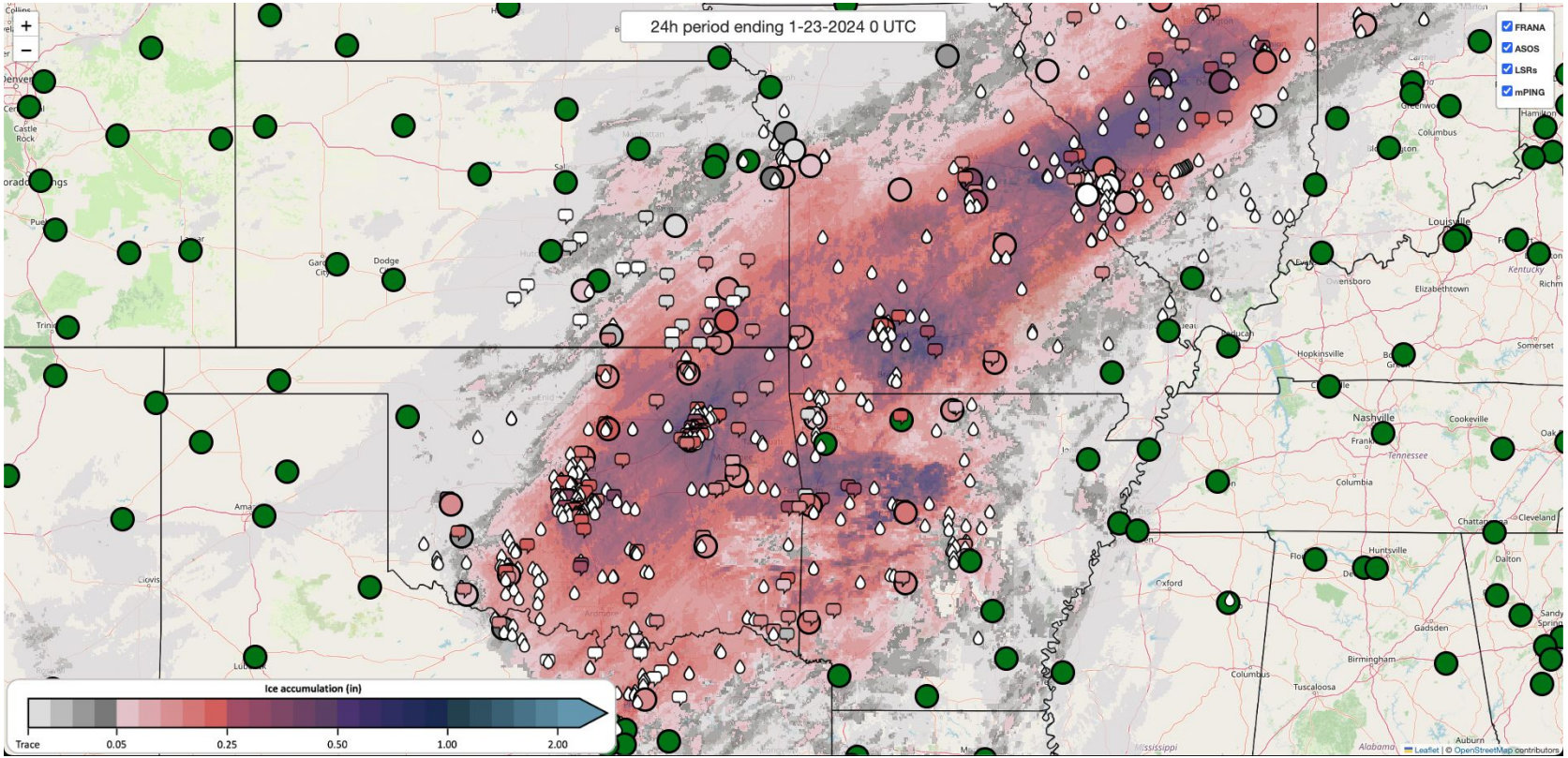



## AWIPS Live Data (LDM)

**NWS Forecasters:** These grids can be ingested into AWIPS at your office. In AWIPS, this will be at the bottom of the MRMS menu (see picture). If you are missing data, contact your regional headquarters for assistance.



# FRANA Automated Verification Maps (publicly visible)




[Verification Map Link]

*Verification maps work best using Google Chrome*

# How can I provide feedback?

## Google Feedback Form

Find something good or bad… let us know! You can contact us directly or fill out the google form below.

**Google Reporting Form:**
https://forms.gle/TTgZ6oMhpKjUCC8H7

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## WWE Forecaster Focus Groups

**NWS Employees Only**
If you use FRANA over the winter, we would appreciate your participation in a focus group that is being hosted in the 2024-2025 Winter Weather Experiment (WWE). If you are interested in participating, please reach out to the WWE coordinators for more details.

**WWE Facilitator**
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