Development of a WPC Excessive Rainfall Outlook "Practically Perfect" Tool for Verification and Forecasting

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WPC's Excessive Rainfall Outlook

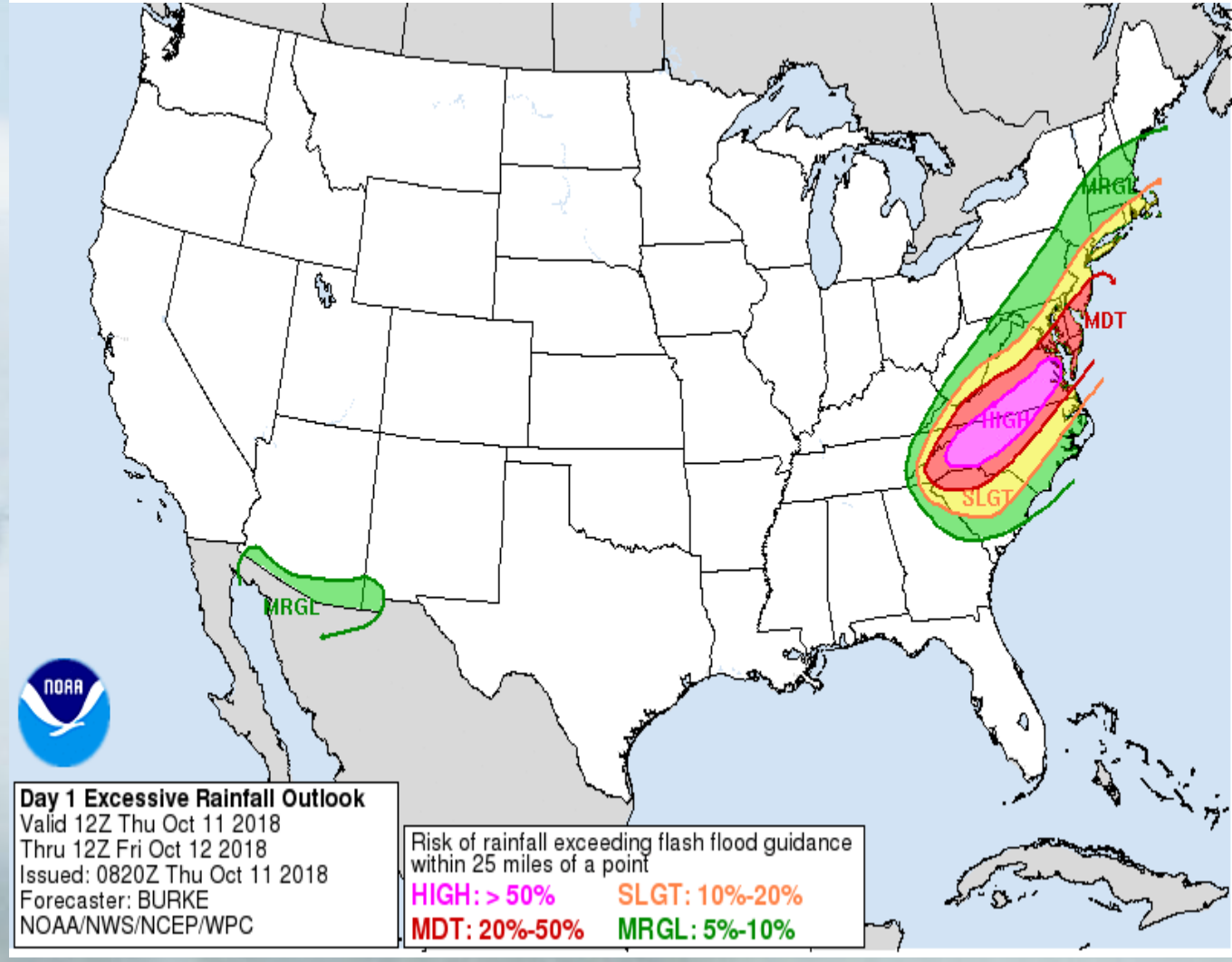
The Weather Prediction Center (WPC) Excessive Rainfall Outlook (ERO) forecasts the probability that rainfall will exceed flash flood guidance (FFG) within 40 km of a point.

There are four categories to the ERO:

1. Marginal (MRGL): 5 – 10 %
2. Slight (SLGT): 10 – 20%
3. Moderate (MDT) 20 – 50%
4. High (HIGH) 50% +

Forecasters lack tools to evaluate day-to-day and bulk ERO performance.

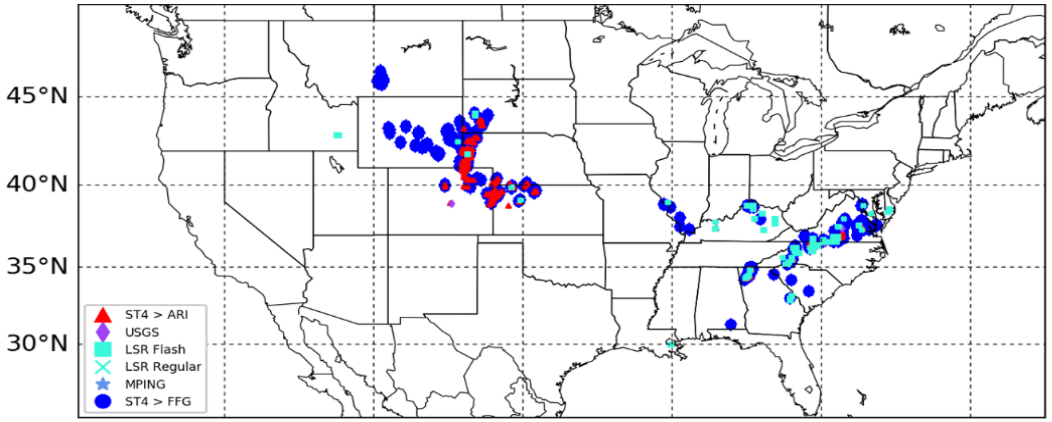
Day 1 WPC ERO Forecast
Issued 09 UTC on 11 Oct 2018



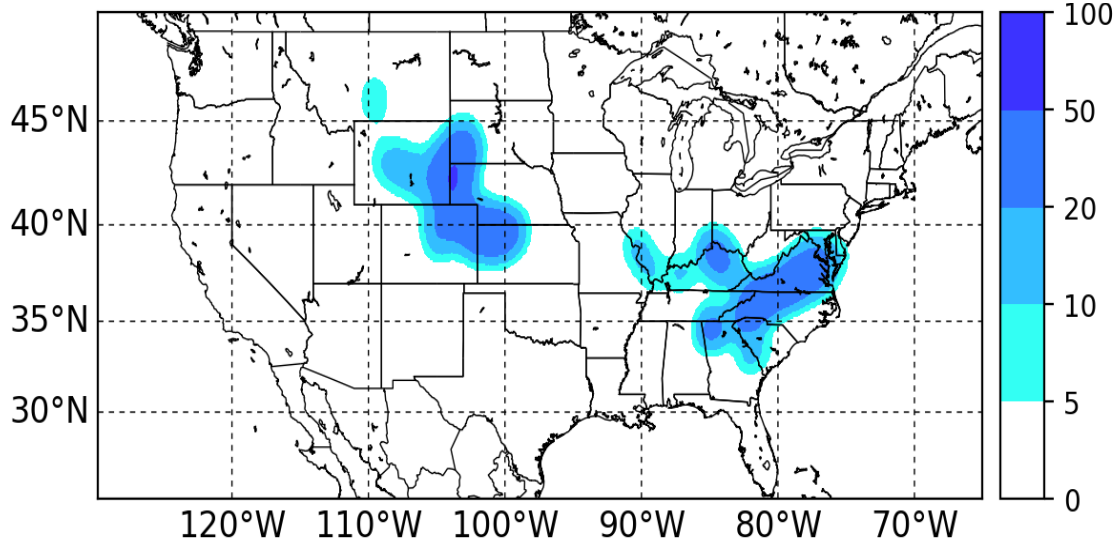
Practically Perfect – What is it?

- Practically Perfect (PP) is meant to represent the best-case forecast given perfect knowledge of the event
- PP is derived from a field of observations/proxies and smoothed to subjectively match the forecast
- There are two tuning parameters to PP:
  1. The Radius of Influence (ROI; e.g. the neighborhood surrounding a flooding observation or proxy)
  2. The degree of smoothing for the Gaussian filter
- **PP must be tuned to the ERO using a retrospective period**

WPC Verification:
Valid 12 UTC 18-19 May 2018



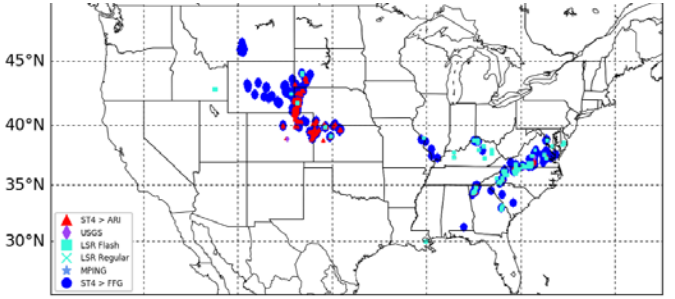
PP 90 km Filter and 40 km ROI
Valid 12 UTC 18-19 May 2018



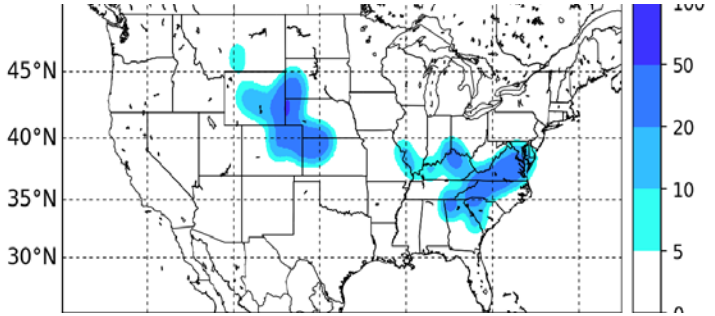
Methods

- There is no single reliable flash flood observation. Hence, WPC uses:
  1. Stage IV exceeding Flash Flood Guidance (FFG)
  2. Stage IV exceeding 5-year Average Recurrence Interval (ARI)
  3. United States Geological Survey (USGS) and Local Storm Report (LSR) observations
- To determine the optimal PP configuration, sensitivity runs are performed from 01 Jan to 31 Dec 2017 by:
  1. Varying the ROI from 5 to 40 km for instances of Stage IV exceeding FFG/ARI (Note: ROI fixed at 40 km for USGS and LSRs)
  2. Varying the Gaussian smoother from 90 to 120 km
  3. PP is generated separately and averaged for A) FFG exceedance, B) ARI exceedance, and C) observations.
- Goal is to **<u>minimize the error and bias</u>** between PP probabilities and ERO probabilities

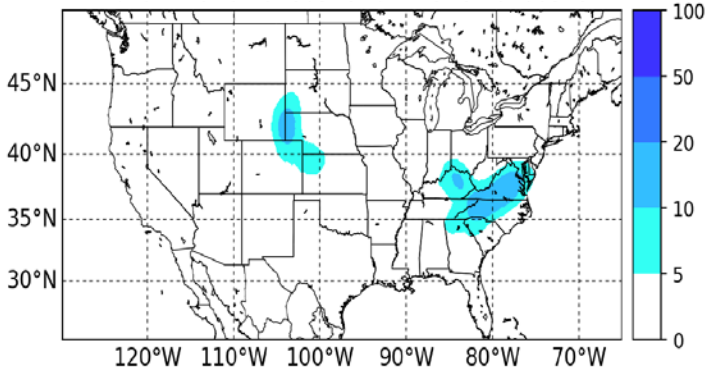
WPC Verification:
Valid 12 UTC 18-19 May 2018



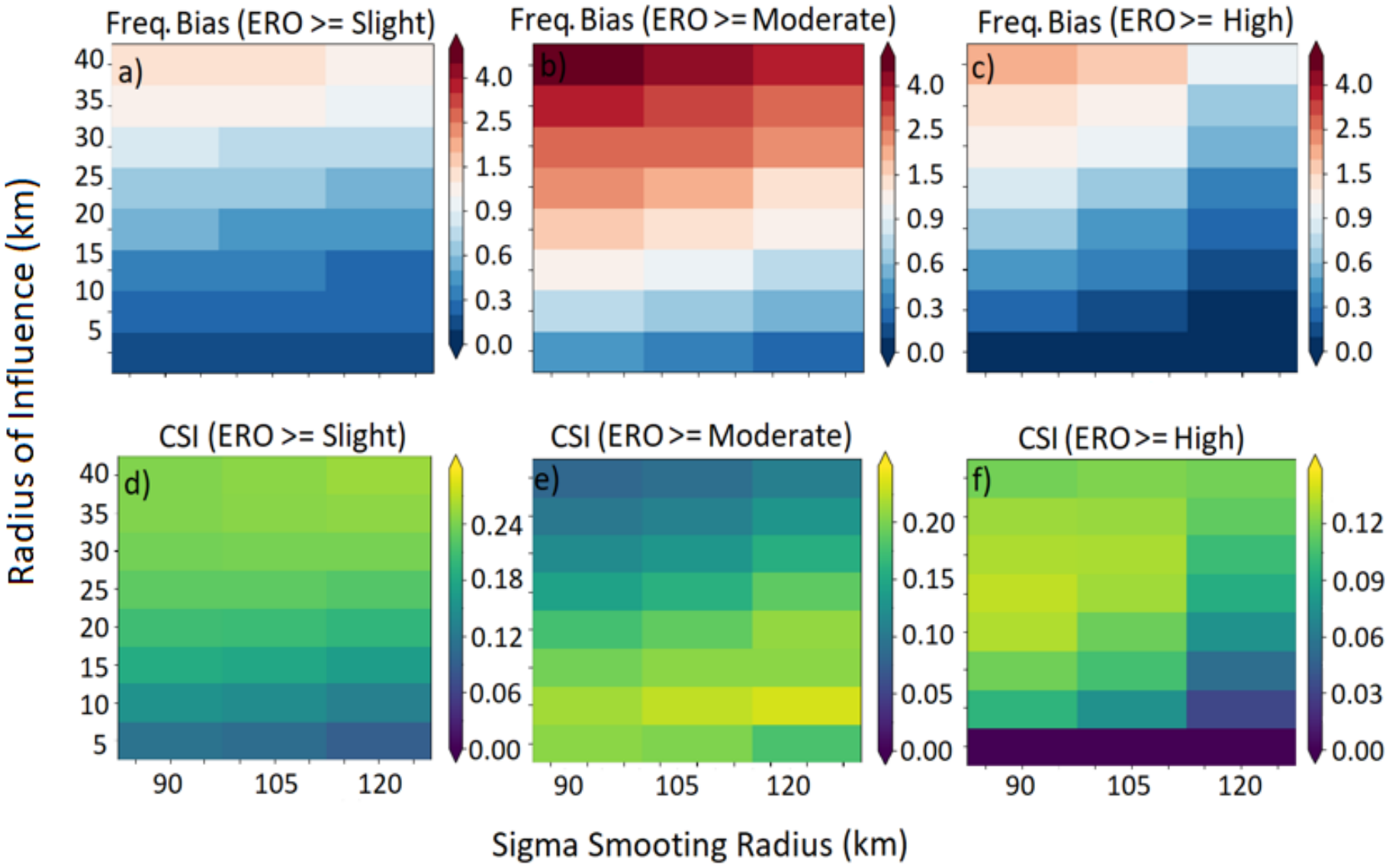
PP 90 km Filter/40 km ROI



PP 90 km Filter/10 km ROI



Frequency Bias (FB) and Critical Success Index (CSI) – Day 1



- The region of zero bias and highest error is identifiable for slight, moderate, and high ERO thresholds.
- The zero bias region is slightly different depending on the ERO threshold.

Optimal Practically Perfect Configuration

Selecting Optimal Configuration

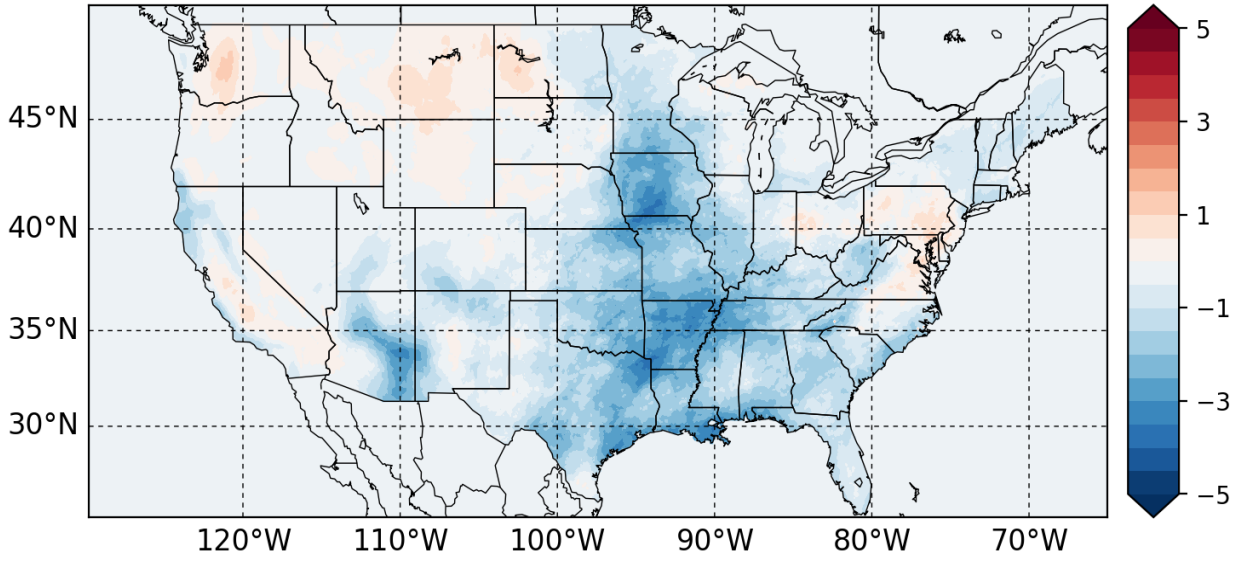
- No error or bias metric tells the whole story. Need to carefully look at what all the metrics are showing while considering their limitations
- FB and CSI results suggest that the **optimal bias/error configuration is around ROI = 25 km; Gaussian filter = 105 km**
- Results with mean error and mean absolute error (not shown) are consistent with FB and CSI.

Applying Optimal Configuration

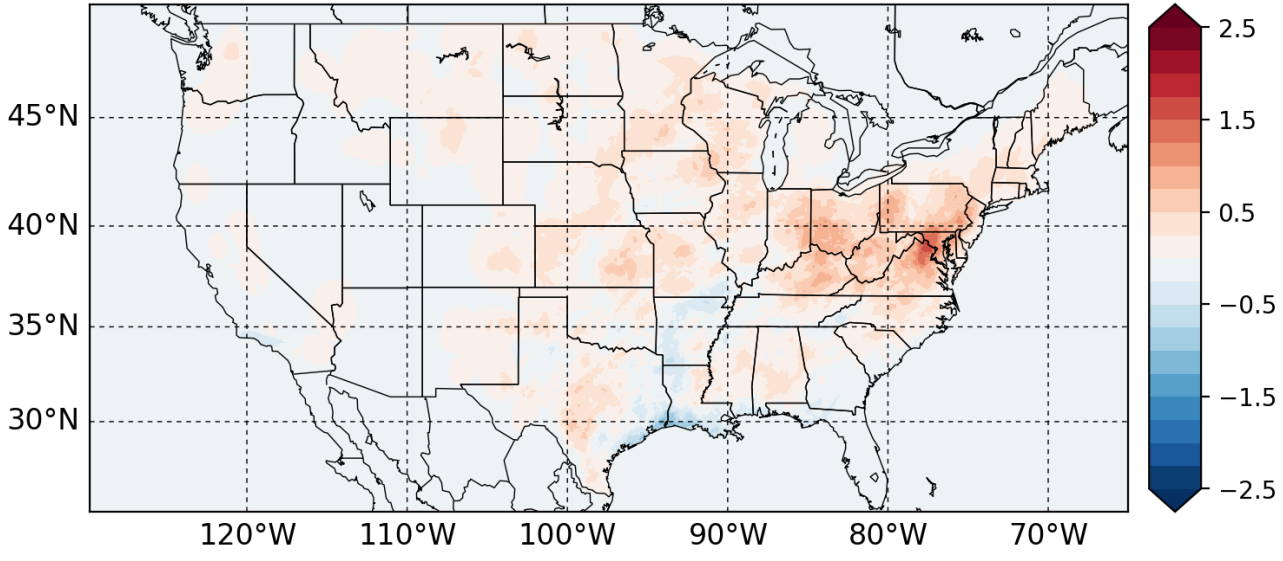
- Practically Perfect has been extended for a longer retrospective period spanning from 01 Jan 2015 to 31 December 2018
- Practically perfect can be used to evaluate spatial and temporal ERO biases/errors

Spatial Bias – Day 1

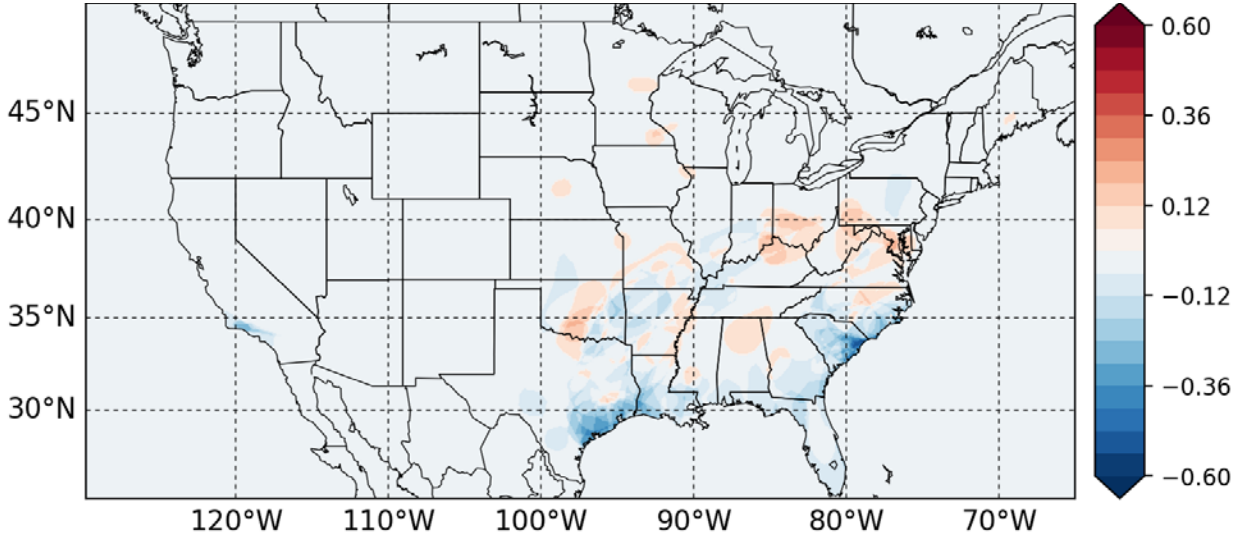
Bias of SLGT



Bias of MDT

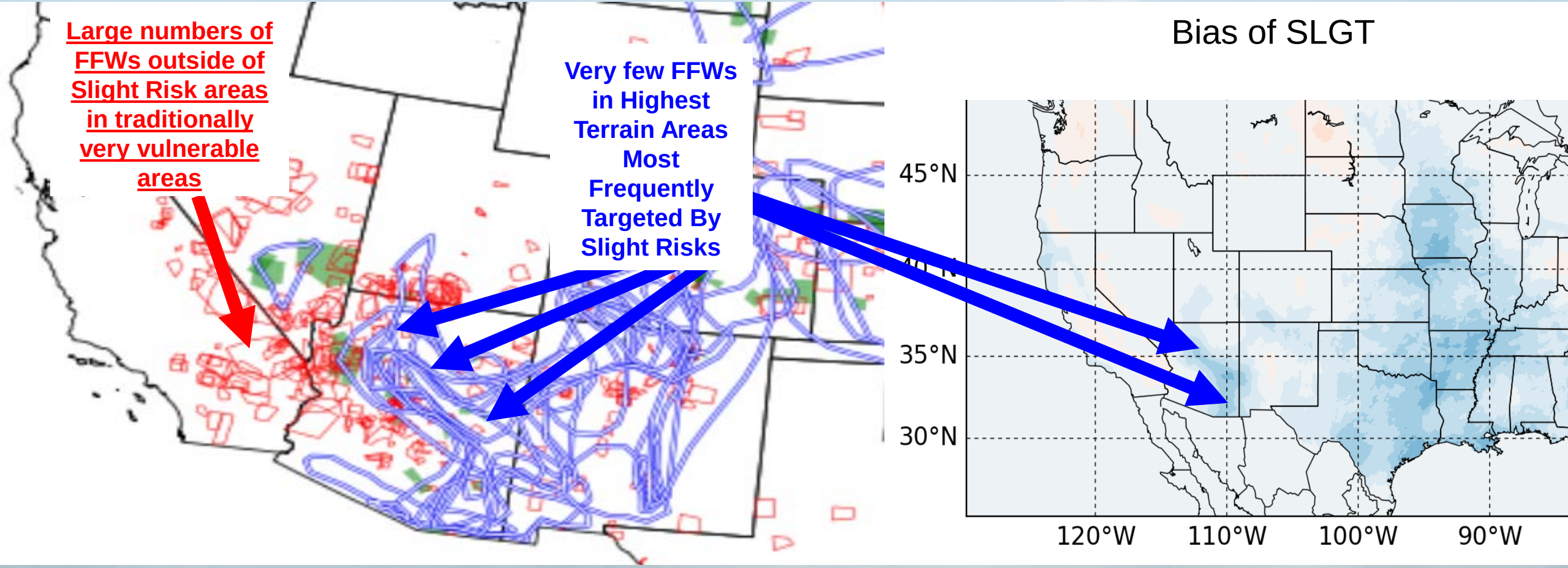


Bias of HIGH



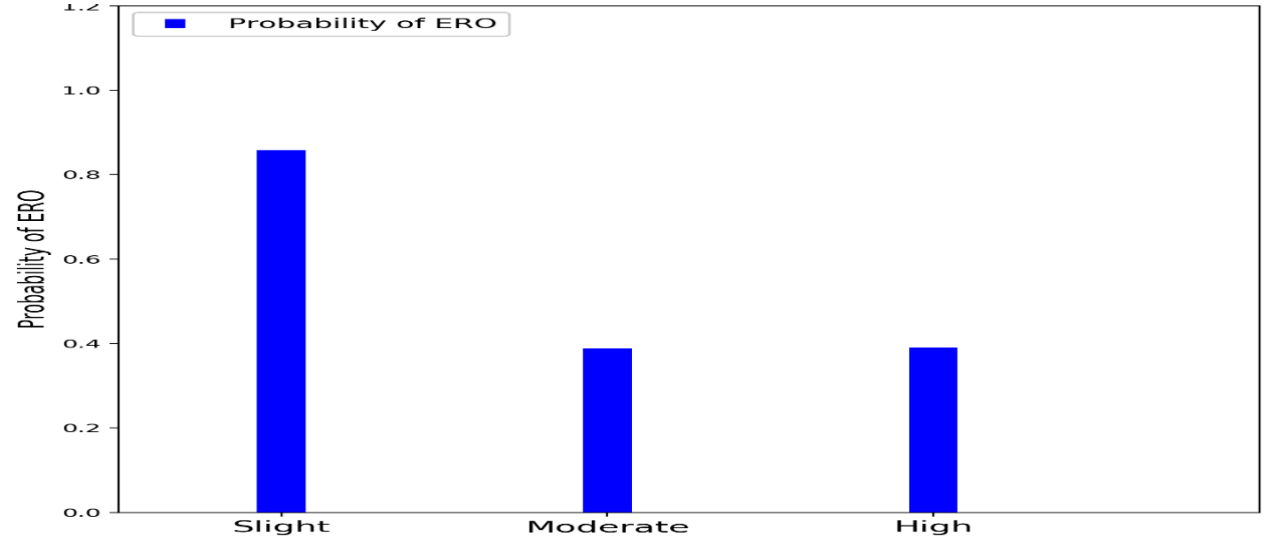
- For SLGT, more EROs are issued than PP over the nation's heartland (e.g. EROs have a positive bias).
- Less ERO SLGTs are issued over western portions of the Southwest, northern High Plains, Pacific Northwest, and Mid-Atlantic
- Since PP itself is biased, these plots are more useful when considering the spatial variability of bias

Monsoon Trends in July 2018 (from Lamars and Carbin; WPC)

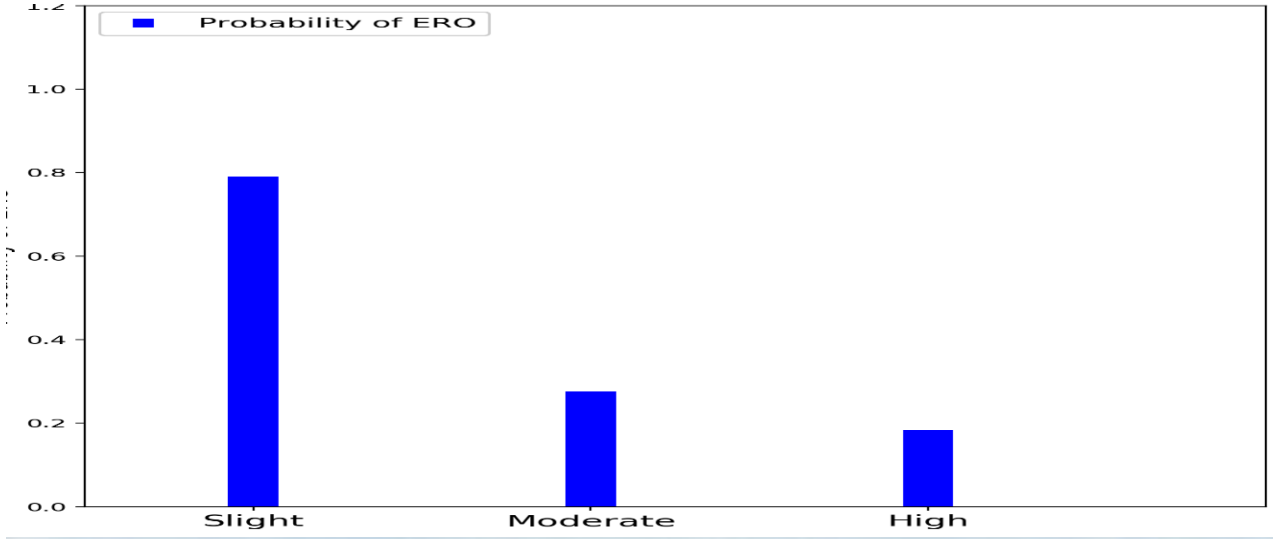


Conditional Probability of ERO Issuance

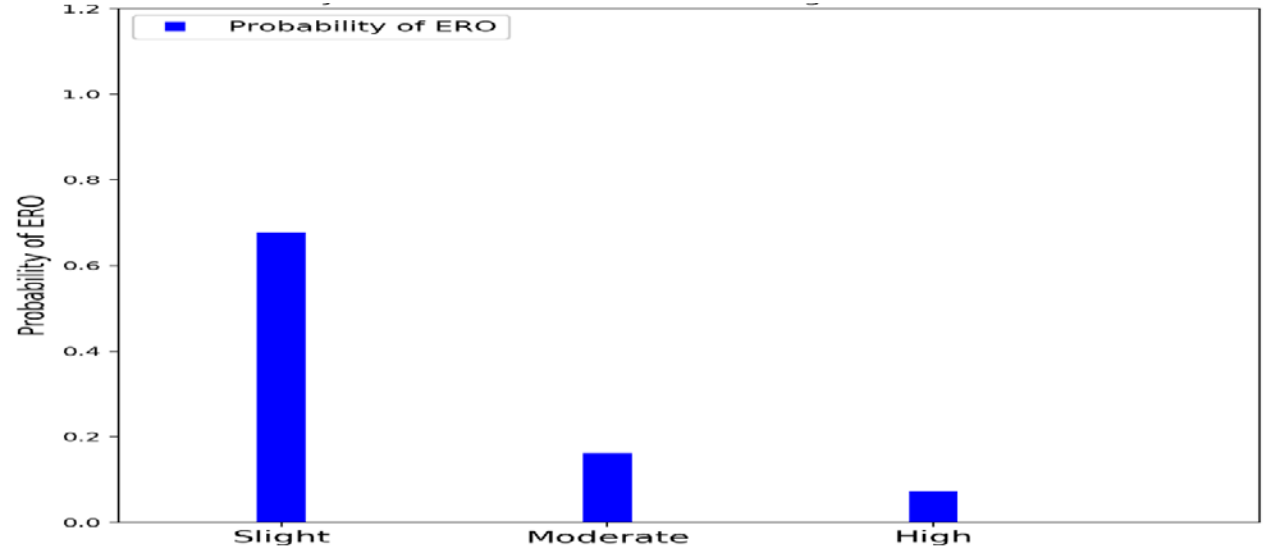
Day 1



Day 2

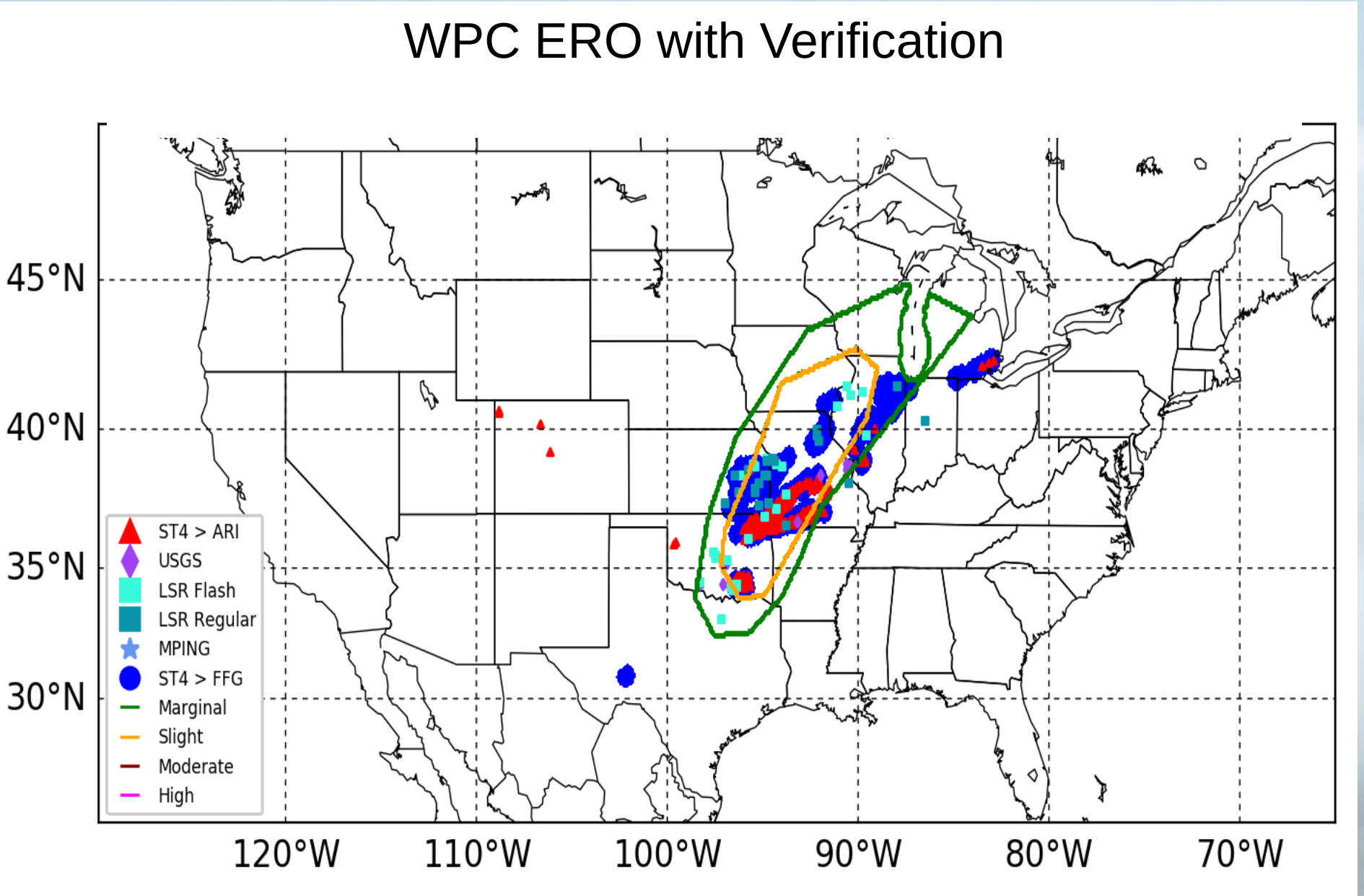


Day 3



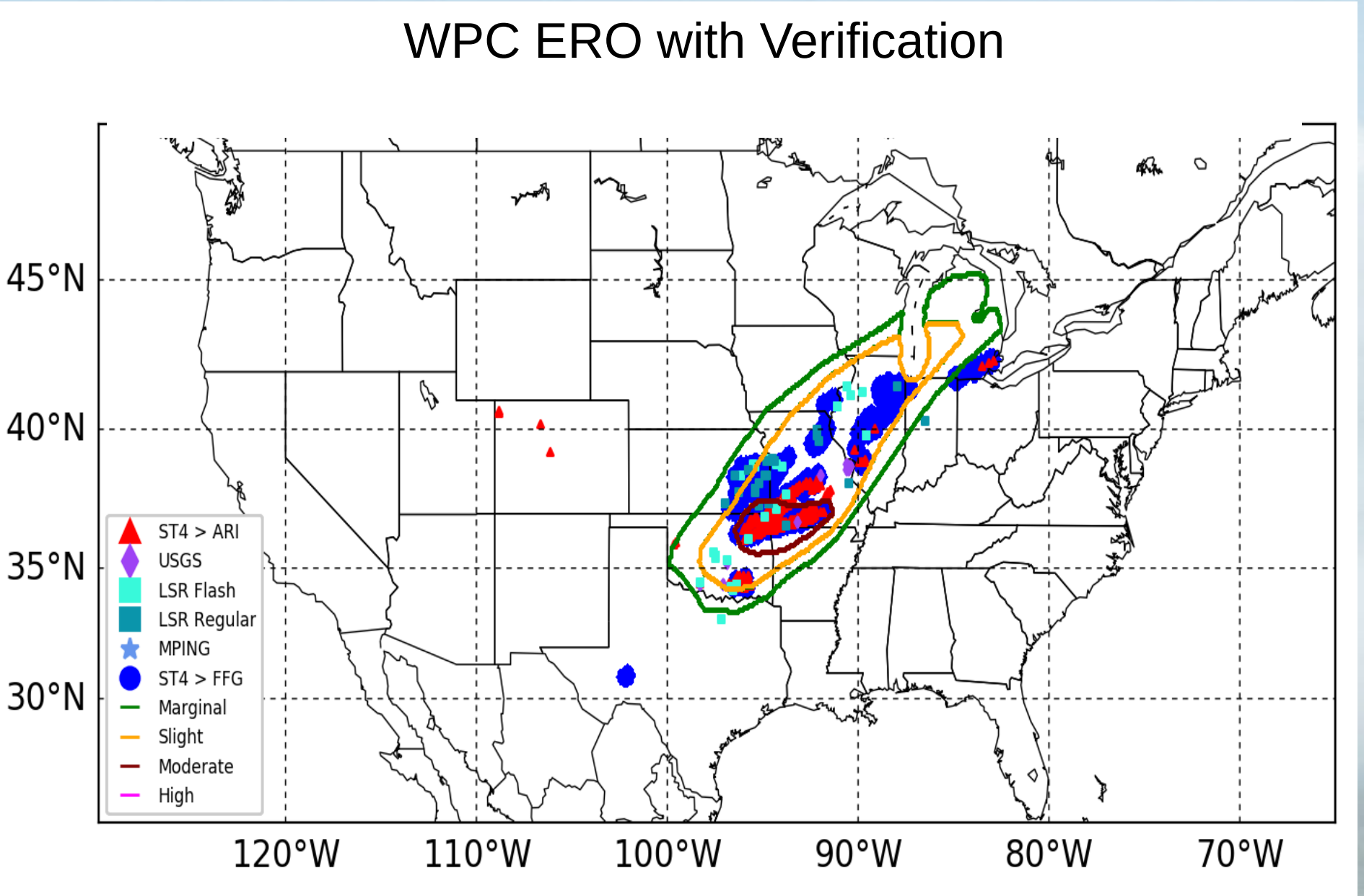
- Presented is the probability of an ERO risk category being issued given the PP risk category is reached
- At day 1, there is a greater than 85% chance of an ERO SLGT being issued when the PP predicts a slight

Practically Perfect – 01 May 2019 Case Study – Day 3



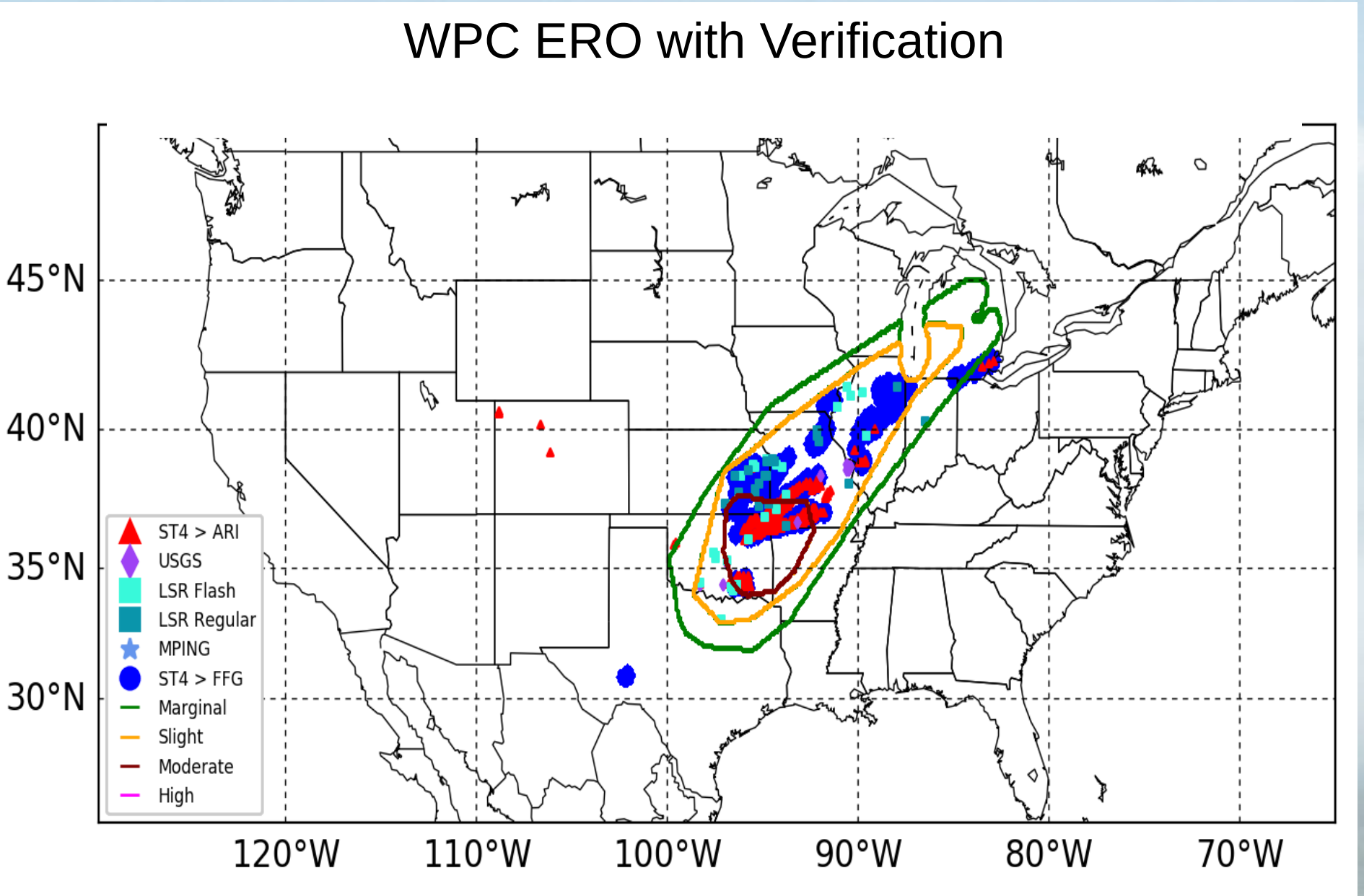
- Day 3 forecast was quite accurate and slightly off with orientation

Practically Perfect – 01 May 2019 Case Study – Day 2



- Day 2 is improved with magnitude (possibly) and orientation

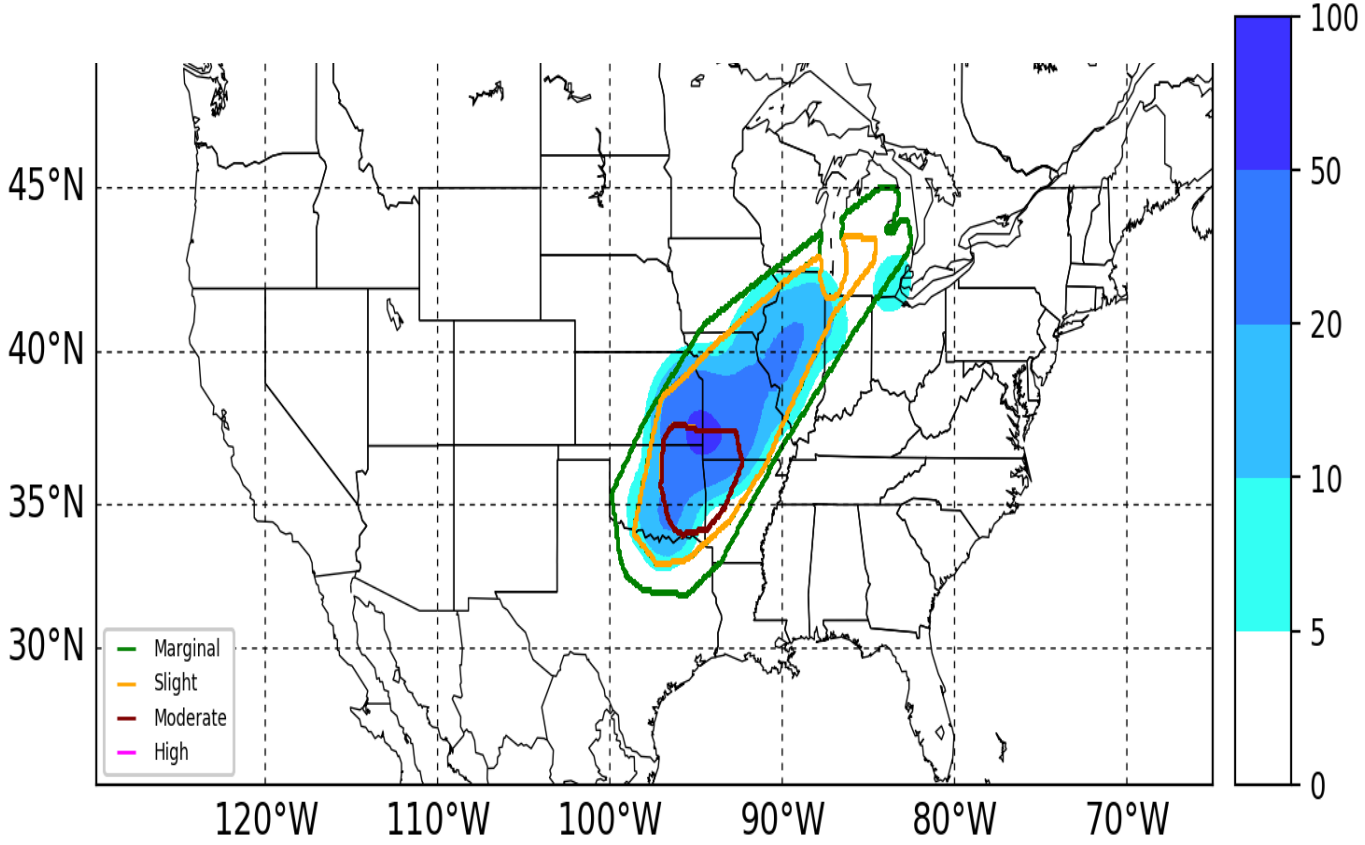
Practically Perfect – 01 May 2019 Case Study – Day 1



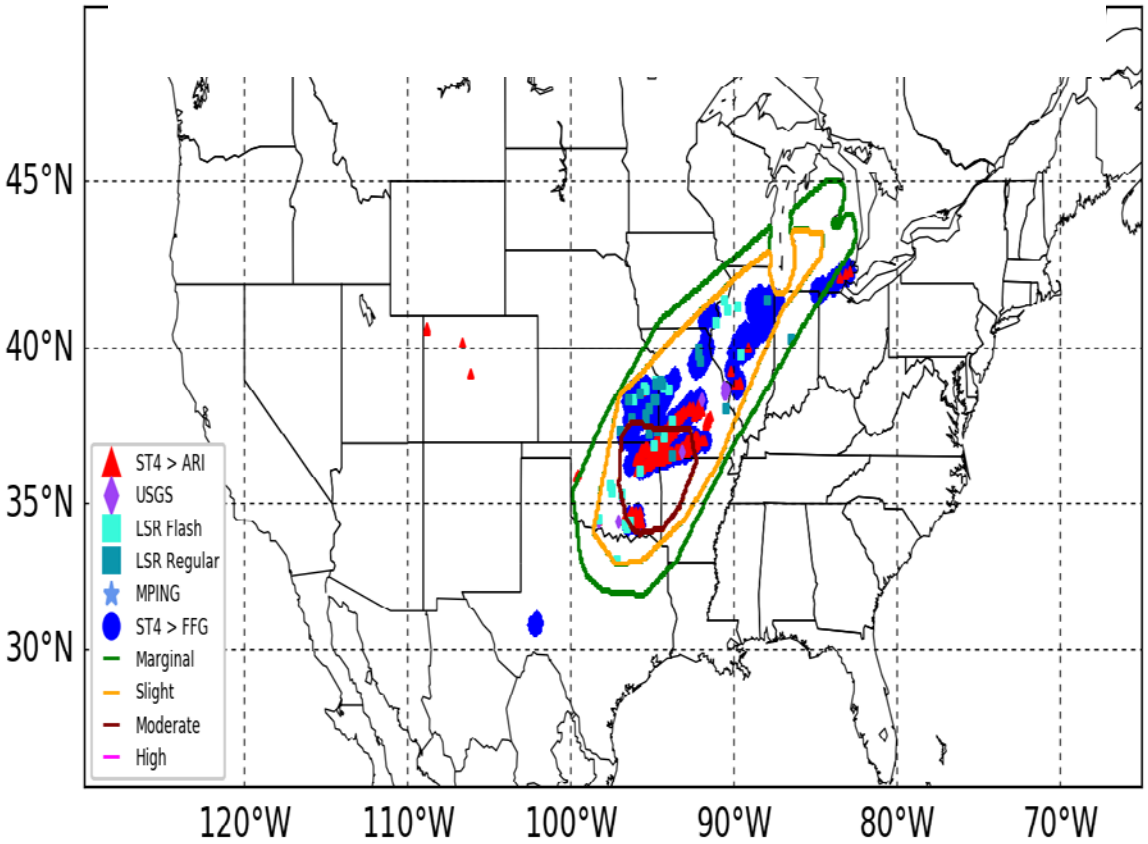
- Day 1 forecast is good with orientation and perhaps a bit too far south with the moderate contour
- Practically perfect can be used to determine if this event reached the moderate threshold

Practically Perfect – 01 May 2019 Case Study – Day 1

WPC ERO with Practically Perfect



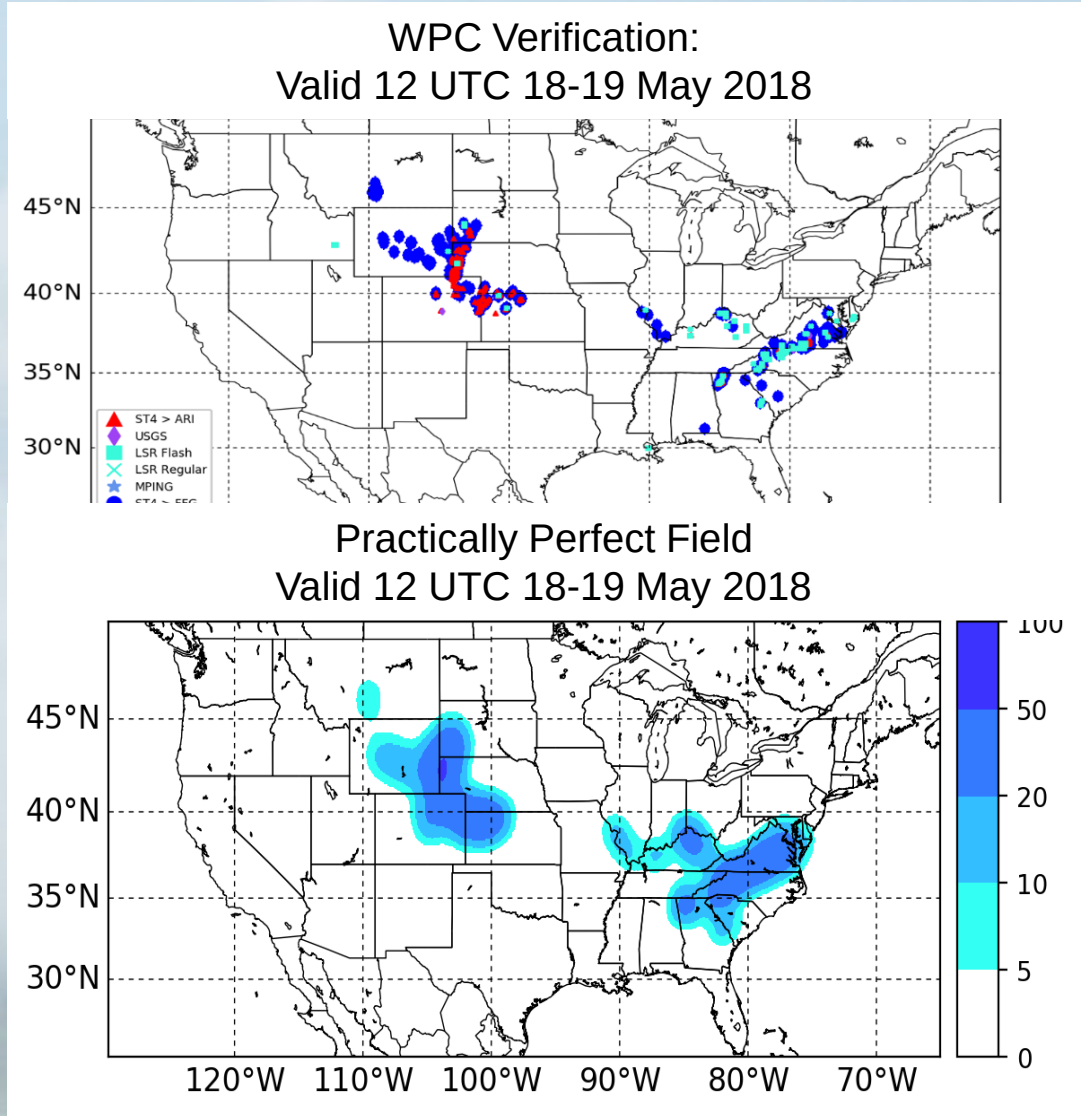
WPC ERO with Verification



- A high in practically perfect requires several types of flooding observations/proxies in a close proximity (FFG exceedances are a dime a dozen)

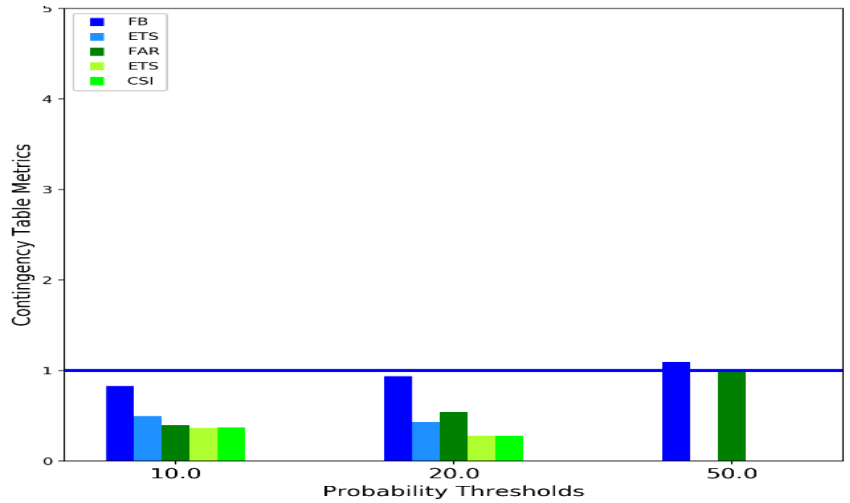
Using PP to Develop a Day 3 ERO First Guess Field

- **Goal:** Create an ERO first guess field using WPC's Probabilistic Quantitative Precipitation Forecasts (PQPF) thresholds
- **Method:** Evaluate instances of WPC day 2/3 PQPF thresholds exceeding:
  1. 1, 3, and 6-hour FFG
  2. 1, 3, 6, 12, 24 hour 5-year ARI
- **Need to conditionalize based on convective regime.** The 95th percentile PQPF threshold is used in all instances of CAPE < 500 J/kg, with varying PQPF thresholds > 500 J/kg (SLGT at 99.9th; MDT at 98th; HIGH at 88th)
- PP methodology is used to create the observation and first-guess based probability fields
- Verification period spans from 6/12/2018 – 8/31/2019.

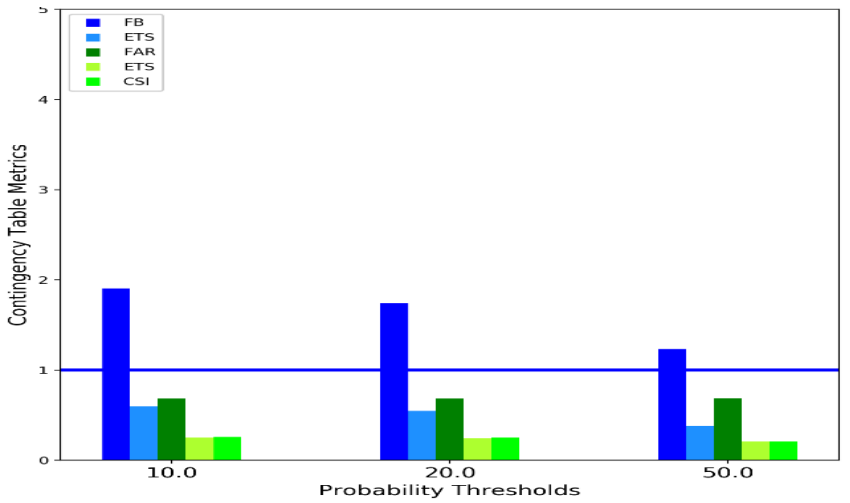


Seasonal Contingency Table Statistics
Day 3

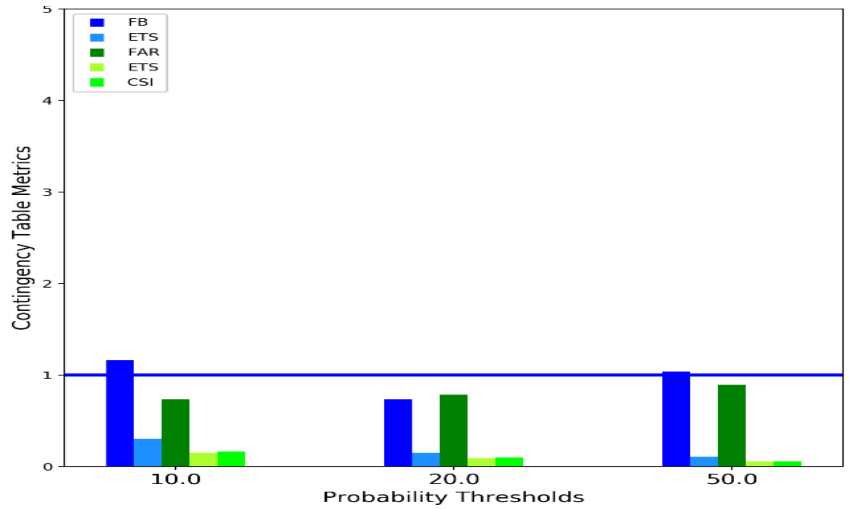
Winter



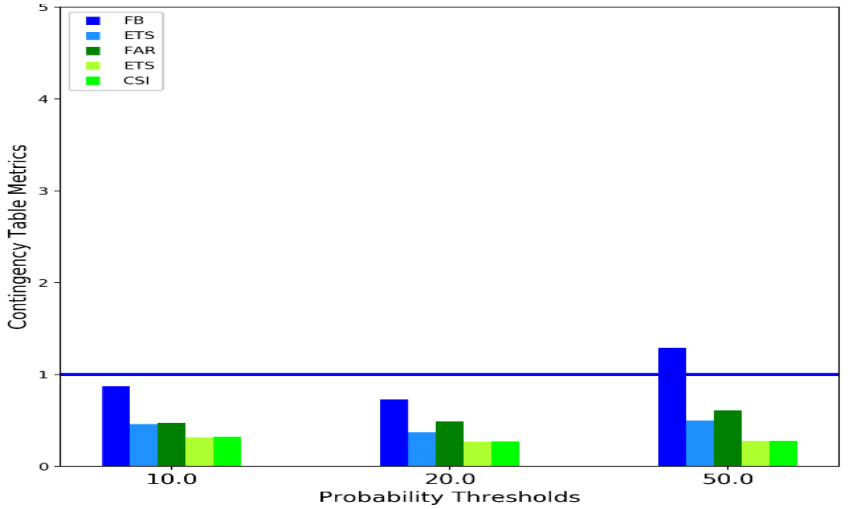
Spring



Summer



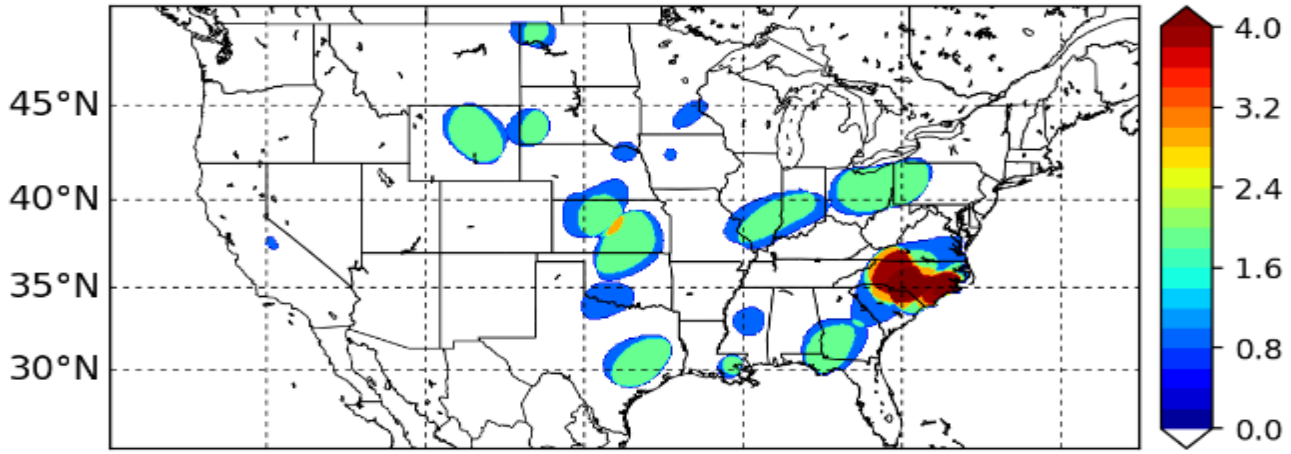
Autumn



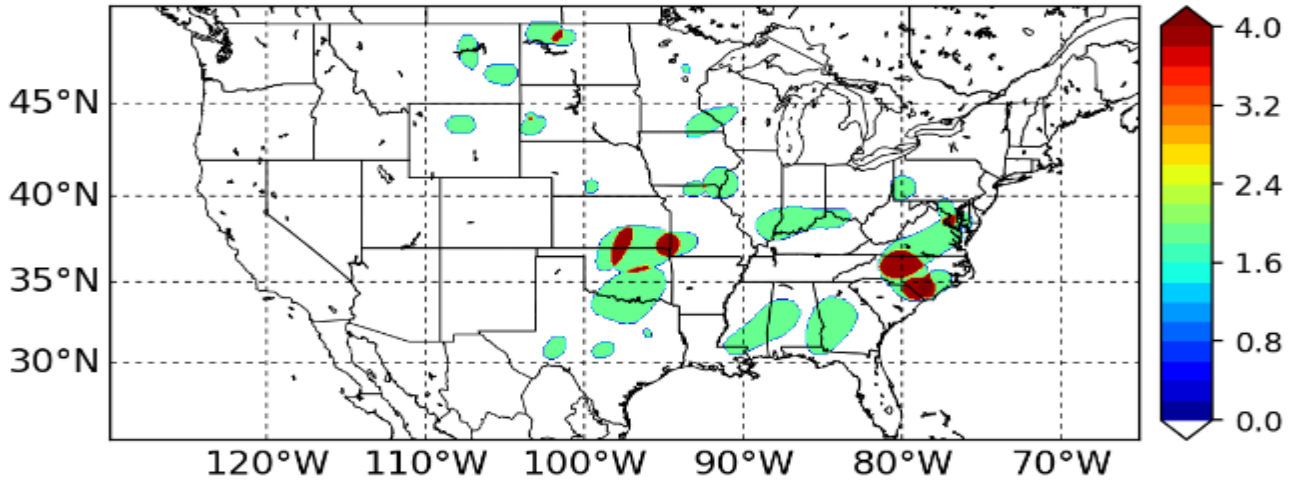
- First-guess field exhibits small bias throughout the year.
- Generally a positive bias in the spring and negative bias in the autumn (difficult to simultaneously correct both).

Spatial Frequency/Calibration of First-guess Versus Observation Based PP

First-guess Occurrence of High

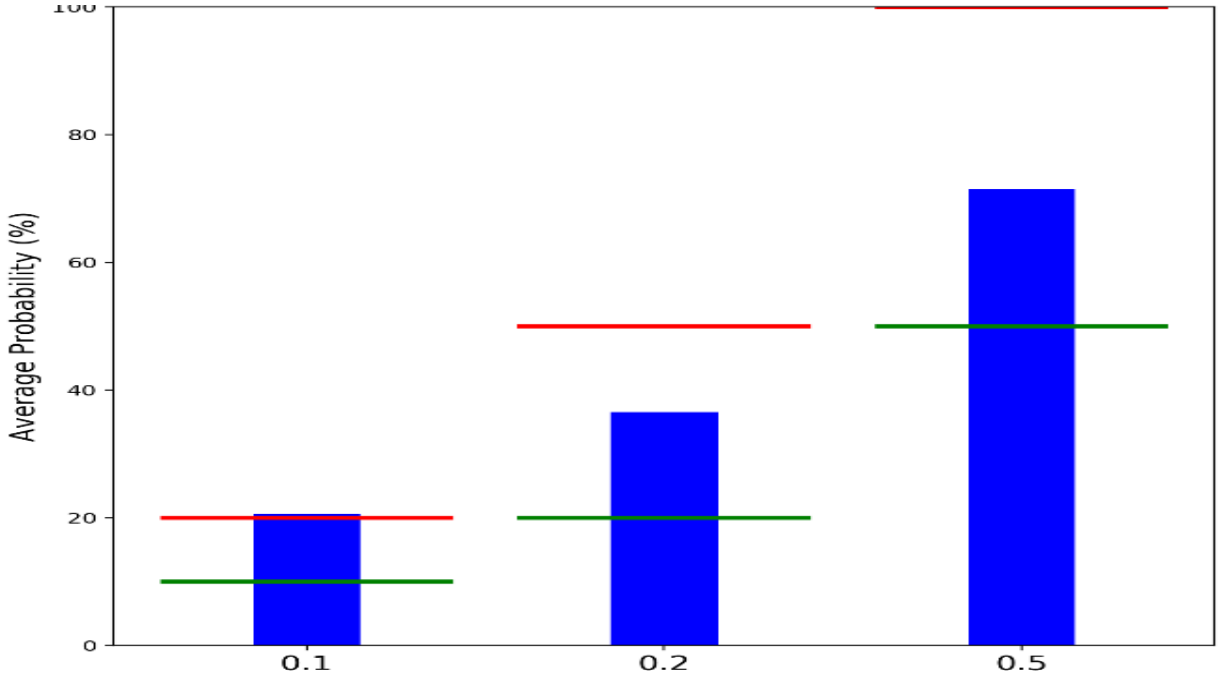


Observed PP Occurrence of High

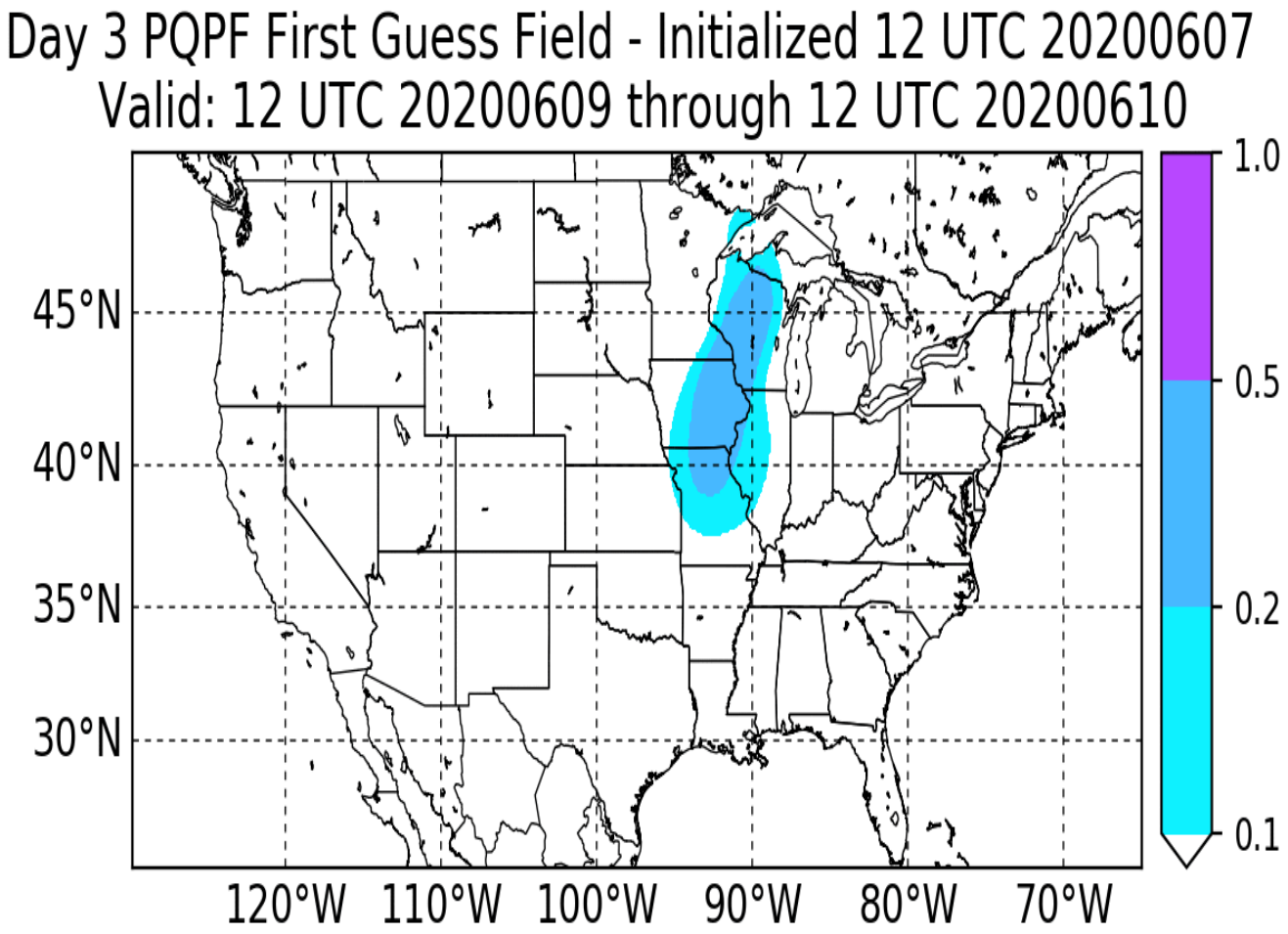


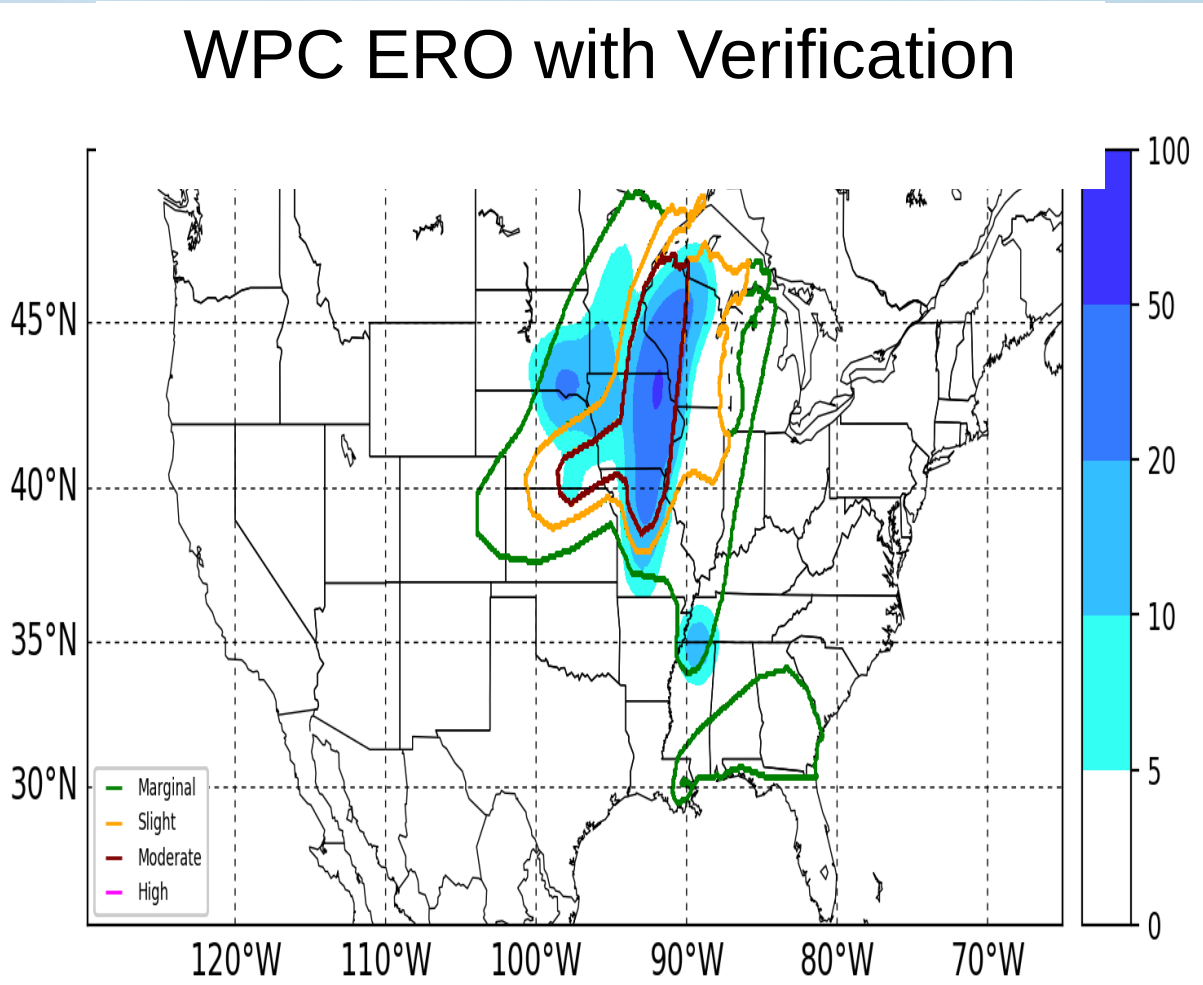
- First-guess occurrence compares well with observations.
- First-guess field is well calibrated for all ERO thresholds, except for SLGT.

Day 3 - Calibration



First Guess Field Example – 06-10 June 2020





- WPC first-guess field did consistently well for Cristobal compared to the operational ERO and observation-based PP field

Conclusions

- Verification results suggest the optimal Practically Perfect (PP) configuration has a **radius of influence of 25 km and a sigma smoothing of 105 km**
- This new PP exhibits a slight negative bias at day 1 and a positive bias at days 2 and 3
- When the PP predicts a slight, there is a 87%, 80%, and 68% chance of an Excessive Rainfall Outlook (ERO) risk being issued on days 1, 2 and 3, respectively
- Applying PP to the Probabilistic Quantitative Precipitation Forecasts (PQPF) results in a relatively skillful and unbiased day 3 first-guess field for the ERO
- Caveats and considerations of the PP method:
  - A Gaussian smoother is used to create these graphics; shapes will be more circular/less complex than reality
  - Not appropriate for predicting the marginal ERO contours
  - May not capture small (meso-alpha) risk regions well