Introducing WPC's New Forecast Experiment: Precipitation Experiment for Atmospheric Rivers (PEAR)

Tomer Burg
CIRES-CIESRDS CU Boulder
NOAA/NWS/Weather Prediction Center

Co-Authors: James Correia Jr., Jim Nelson, Ben Albright

What is HMT?

- The **Hydrometeorology Testbed (HMT)** is part of NOAA's Weather Prediction Center (WPC)

Our objectives:

- Bring together forecasters, researchers, and model developers to **evaluate new models, tools, and techniques** at forecast experiments, in person and virtually
- **Generate insight** from participants through forecast activities, surveys, seminars, and focus groups
- We seek to **bridge the R2O2R gap** by bringing insight from researchers and modelers to WPC and WFO forecasters and vice versa

Forecast Experiments at HMT

FFaIR
Flash Flood and Intense Rainfall Experiment

- Focus on summer excessive rainfall and flash flooding

WWE
Winter Weather Experiment

- Wintertime snow & frozen precipitation forecasting

PEAR
Precipitation Experiment for Atmospheric Rivers

- New forecast experiment spinning up in Fall 2024

Motivation for PEAR

- The **Water in the West** project plan includes support for a new forecast experiment at WPC to improve AR prediction
- New experimental models to predict ARs were developed with a high-resolution configuration, focusing on 2022-23 retrospective cases
- Previously, high-resolution AR specific models have not been available to forecasters at medium-range lead times - how might forecasters make use of this data?
- AR prediction has not yet been a focus of forecast testbed activities at NOAA – **HMT wants to learn more about the AR forecasting process**

PEAR Objectives

1. Evaluate utility of experimental high-resolution models for predicting AR impacts:
   - **AR-AFS:** Environmental Modeling Center (EMC)'s limited area model with ~3km horizontal resolution
   - **UFS-AR:** GSL's nested high-resolution model for predicting ARs
2. Conduct **focus group activities** focused on identifying the forecast challenges and objectives for AR prediction at medium and short range lead times
3. Gauge participant feedback to **inform model development and PEAR design** for future experiments

PEAR Daily Schedule

Atmospheric River Forecast Experiment

Fall 2024 Schedule
Pacific time

Day 1: Focus Group

8:15am – 9:30am PT
Intro & icebreaker

9:45am – 11:00am
Focus group activity 1: Review of AR forecasting by lead time

11:00am – 12:00pm
Lunch

12:00pm – 1:30pm
Focus group activity 2: Review of potential AR forecast activities

1:45pm – 3:00pm
Focus group continued

3:00pm – 4:00pm
Discussion

Day 2: Forecasting

8:30am – 9:00am
Day 5 forecast briefing

9:00am – 11:00am
Day 5 forecast activity

11:00am – 12:00pm
Lunch

12:00pm – 12:20pm
Day 3 forecast briefing

12:20pm – 1:50pm
Day 3 forecast activity

2:00pm – 2:20pm
Day 1 forecast briefing

2:20pm – 4:00pm
Day 1 forecast activity

Day 3: Discussion

8:30am – 10:00am
Forecast verification

10:00am – 11:00am
Discussion: how does forecast activity link to model utility, how useful are high resolution models

11:00am – 12:00pm
Lunch

12:00pm – 2:00pm
Discussion and wrap up: feedback for forecast activity, model developers, R2O and O2R

PEAR Forecast Activities

- The first PEAR featured multiple text-based and drawing forecast activities for ARs at 5, 3, and 1 day forecast lead times
- Our goal for these forecast activities was to keep them relatively vague and open-ended, with little quantitative verification
- By having forecasters subjectively perform these forecast activities, the objective was to gain insight into the thought process that goes into forecasting ARs at different forecast lead times

PEAR Forecast Activities

- The following models were made available to participants for forecast activities and discussions:

Operational: GFS

Experimental: AR-AFS (EMC), UFS-AR (GSL), West-WRF (CW3E)

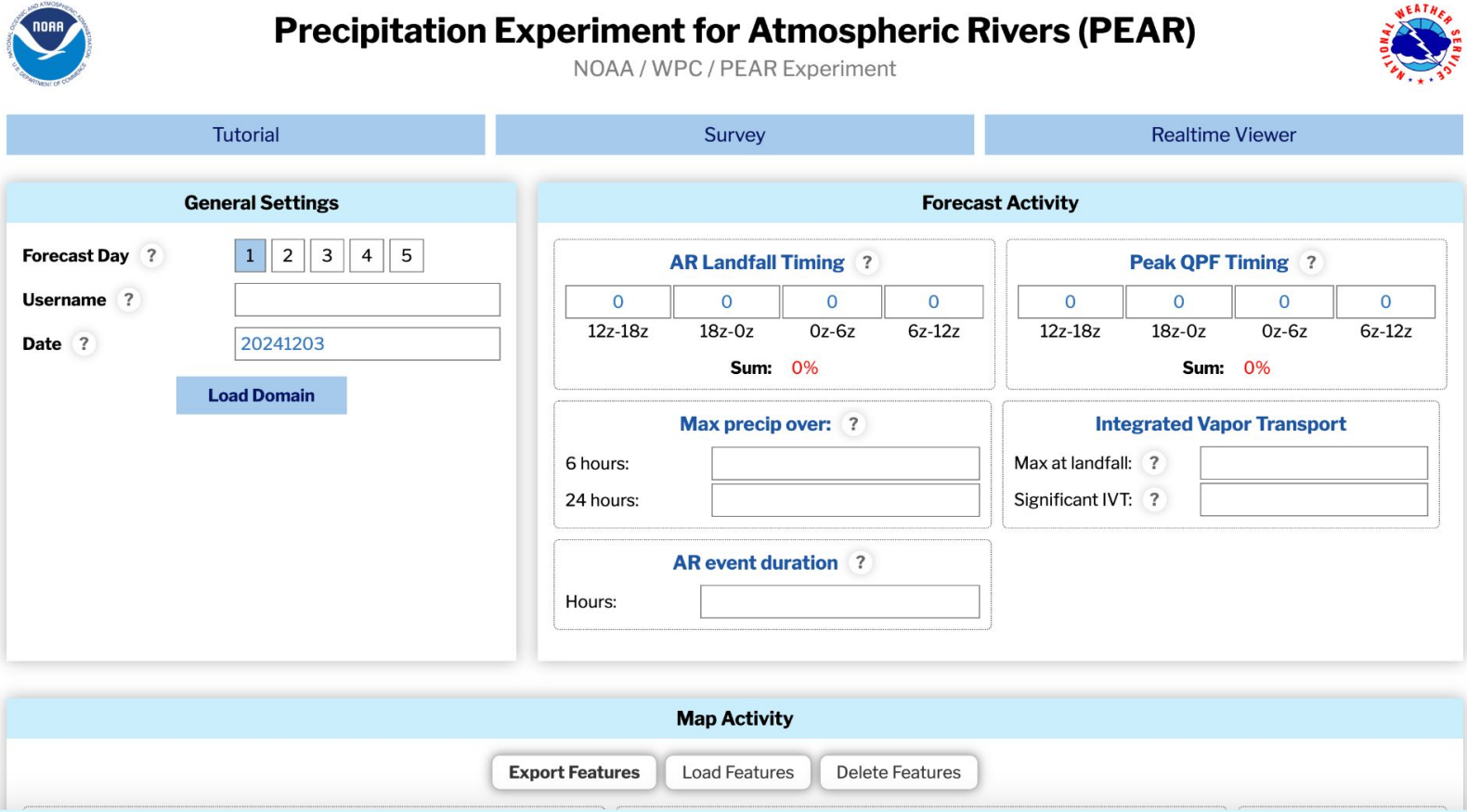
- For forecast briefings, we also made use of satellite-derived precipitable water plots courtesy of CIRA and Chris Smith

- UFS-AR was only available at day 1 lead time

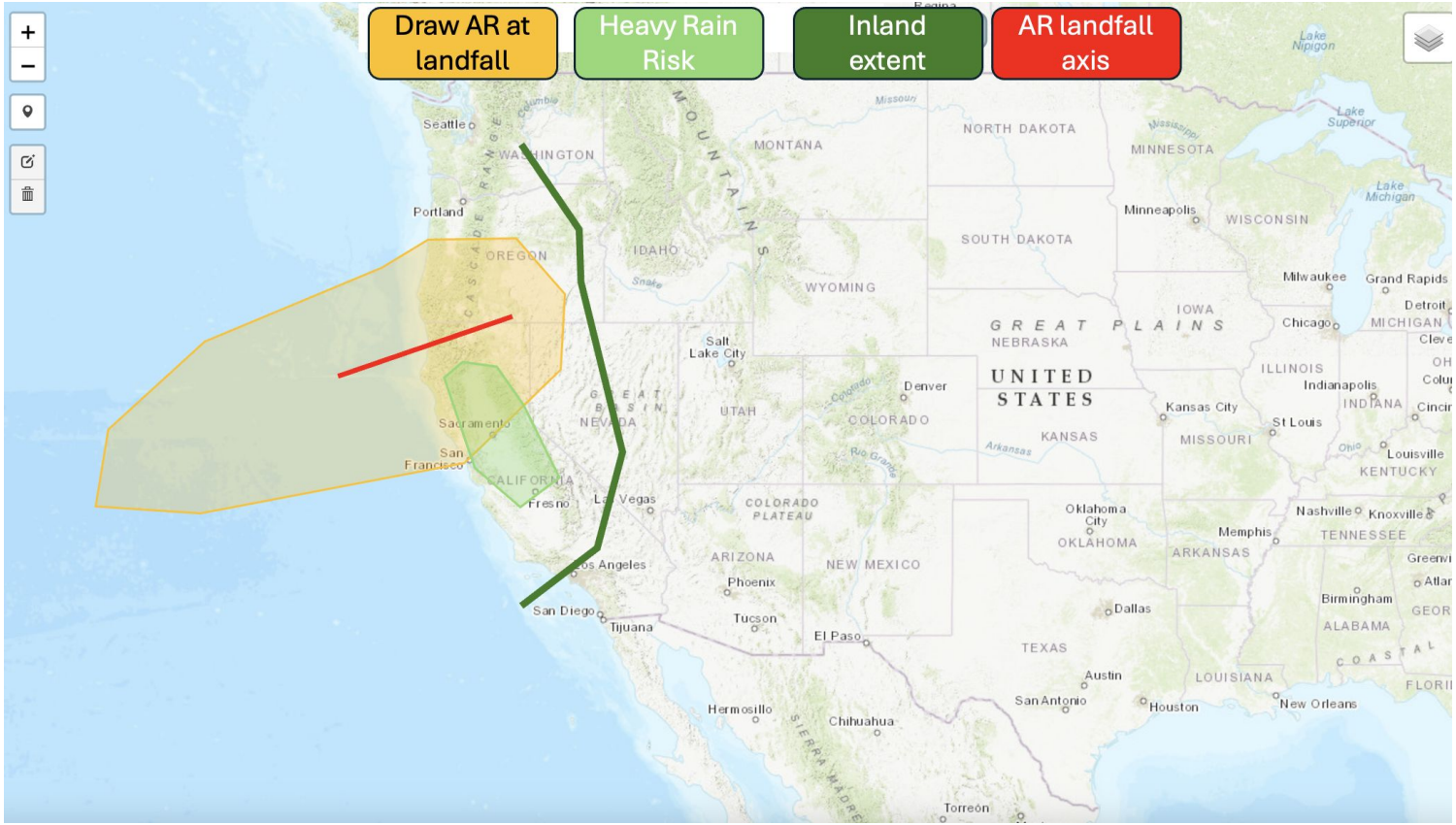
PEAR Focus Group Activities

- The focus group aim was to learn more about what forecasters care about most when forecasting AR impacts and for messaging
  - What factors influence decision making in the medium range? At what lead times do forecasters begin to make these decisions?
  - What are the short term phenomena forecasters care about most? Do high-resolution models predict them well?
  - How does the importance of AR characteristics, location and timing forecasts vary by forecast lead time?
  - What QPF thresholds matter most (e.g., 6/12/24/48 hour QPF)?
  - How do high-resolution models for ARs at extended lead times affect the forecasting process?

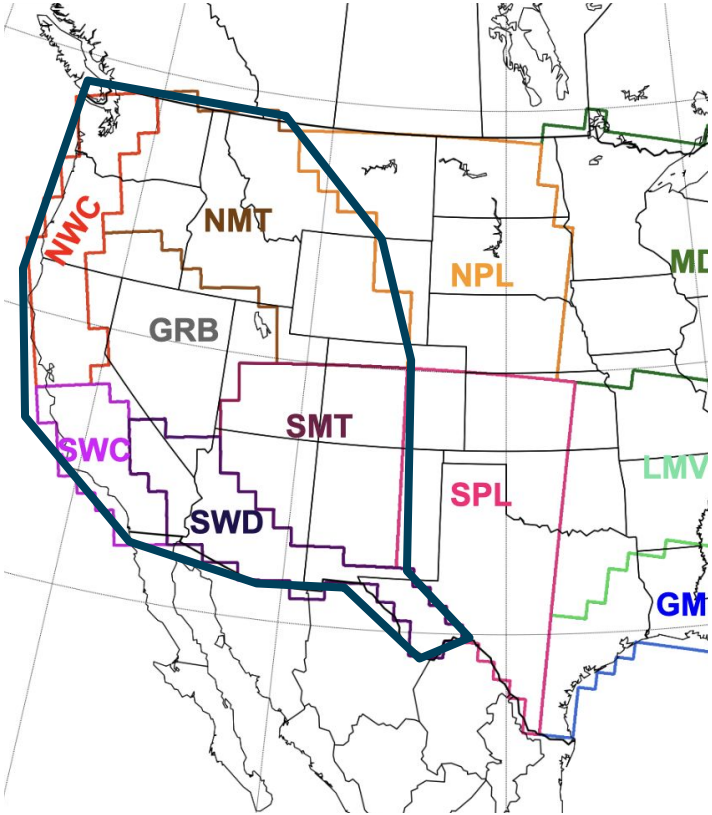
PEAR Forecast Activities



PEAR Forecast Activities

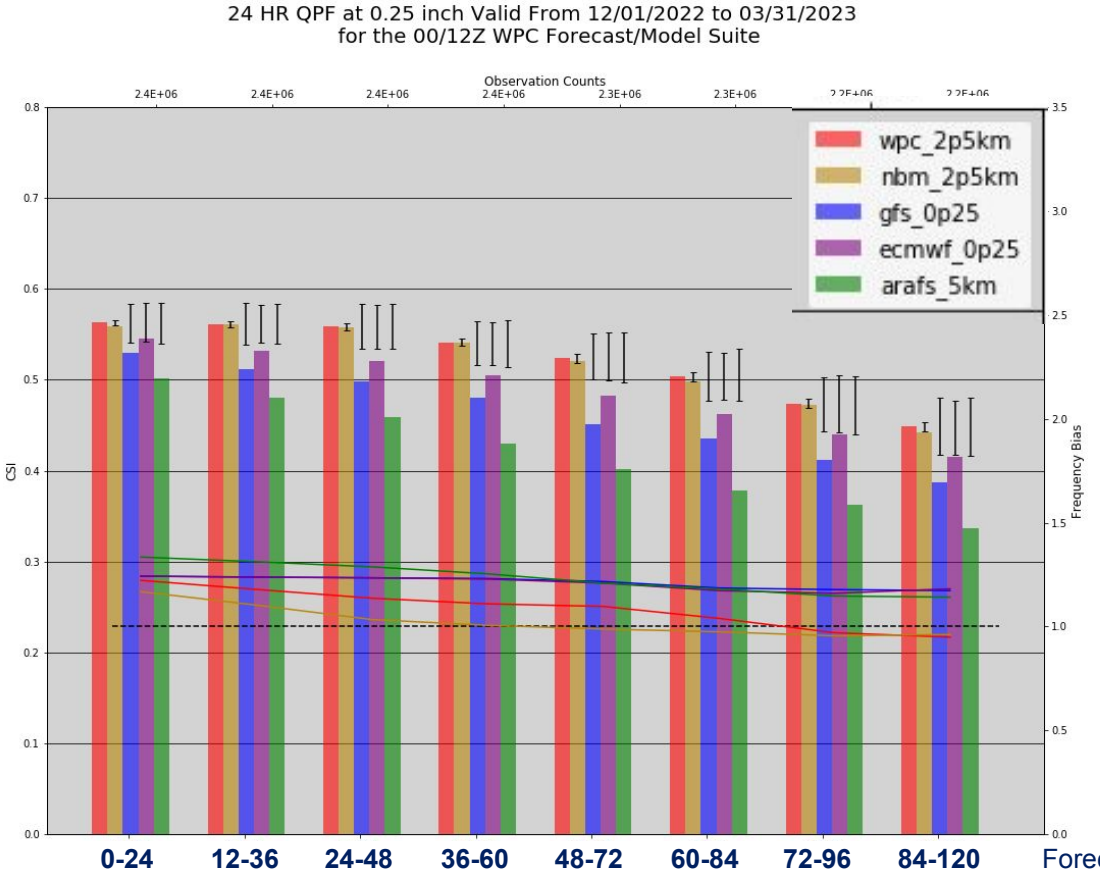


QPF Verification – AR-AFS



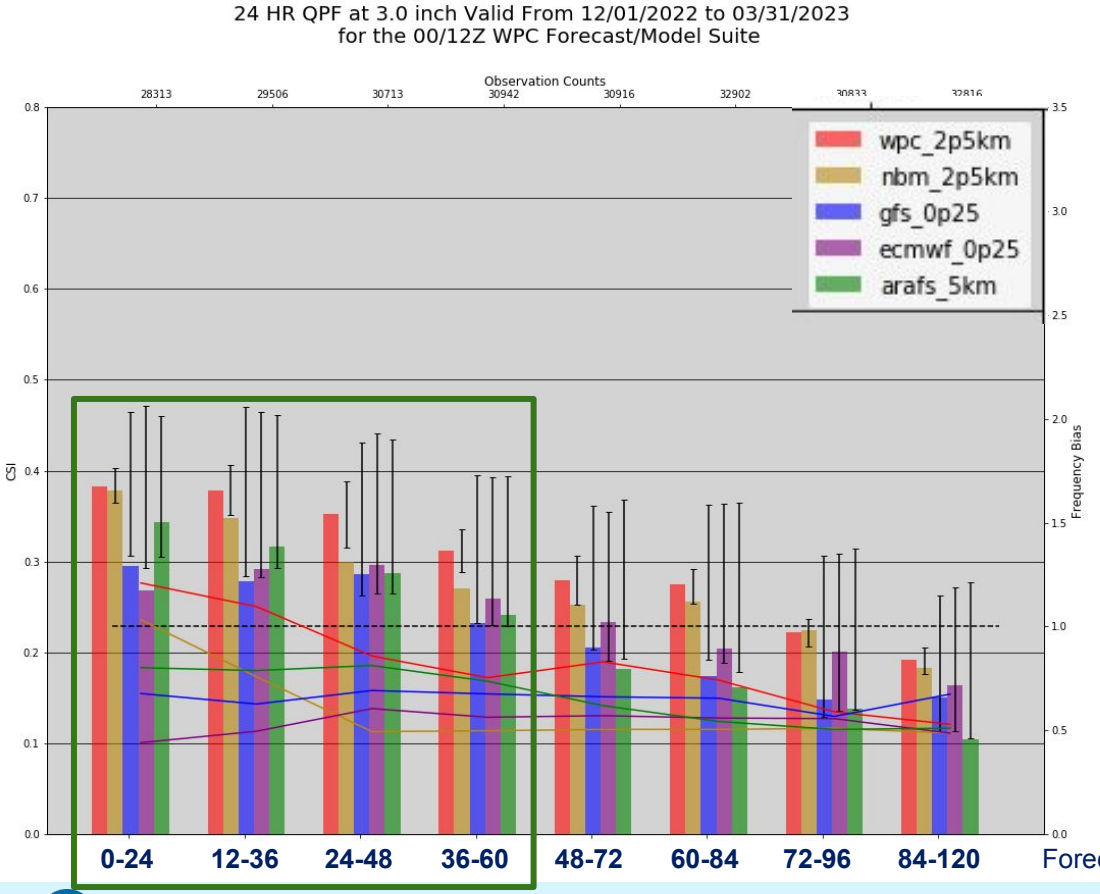
- Ben Albright performed QPF verification for WPC, operational models, and AR-AFS for December 2022 – March 2023 in western regions
- These verification statistics were only compiled for cycles and forecast hours where all model guidance was available
- Individual QPF maps for subjective case study evaluation were also produced

QPF Verification – 0.25 Inch CSI



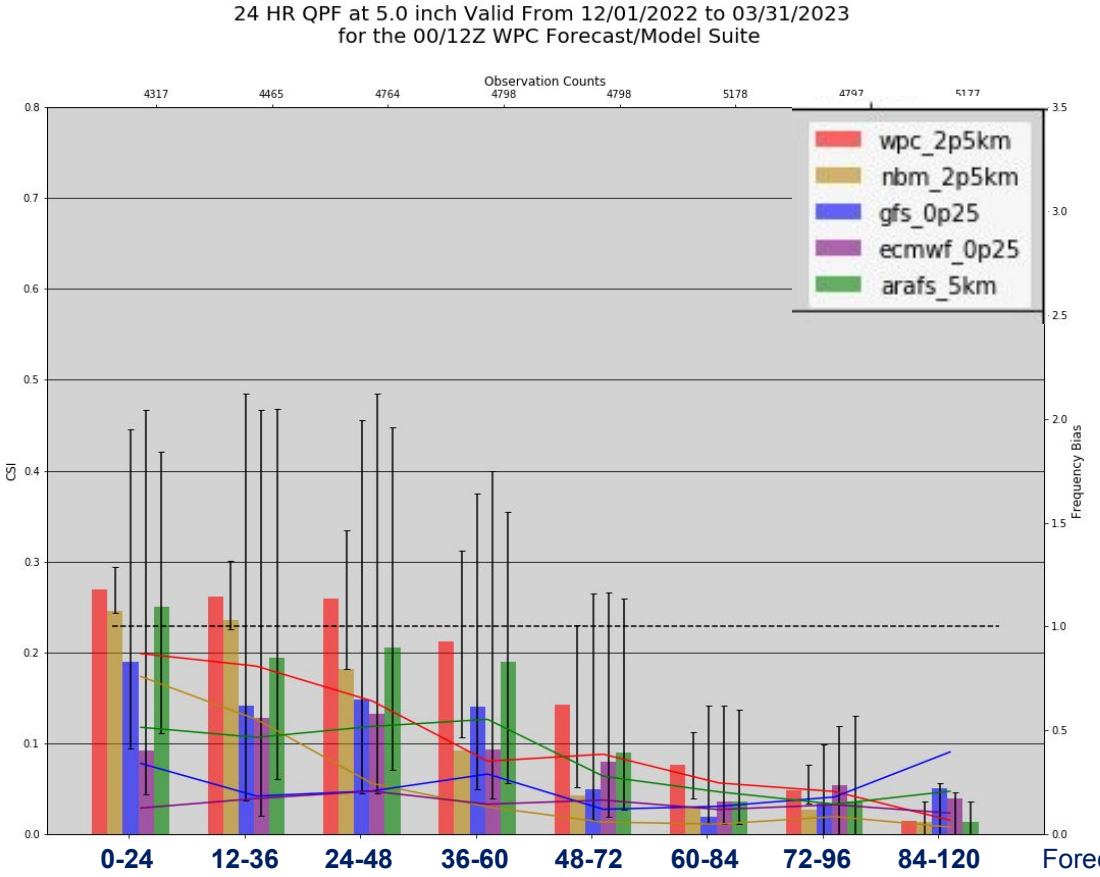
- For low QPF thresholds, **WPC (orange)** has the highest CSI, **AR-AFS (green)** has the lowest CSI

QPF Verification – 3.0 Inch CSI



- **AR-AFS (green)** begins to catch up to other global model skill scores at short lead times for higher QPF thresholds

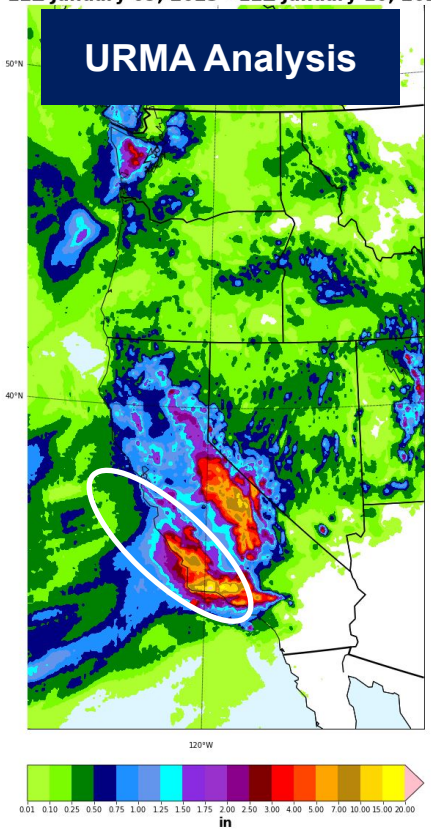
QPF Verification – 5.0 Inch CSI



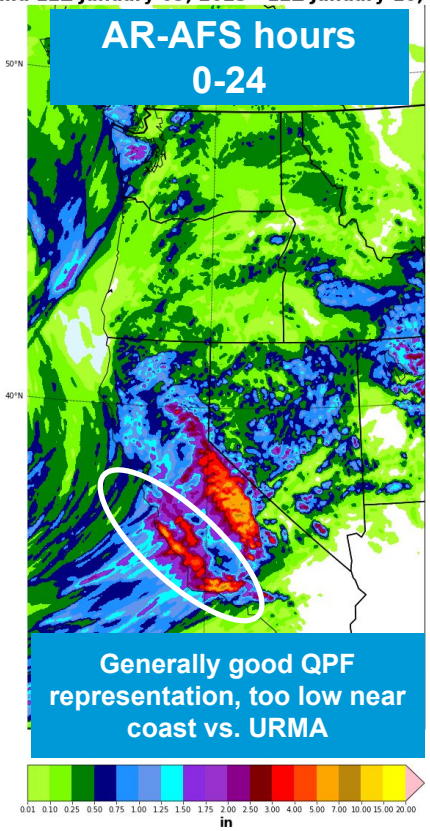
- For the high-end QPF thresholds, **AR-AFS (green)** outperforms most global models, generally second to **WPC (orange)** forecasts

AR-AFS Subjective QPF Evaluation

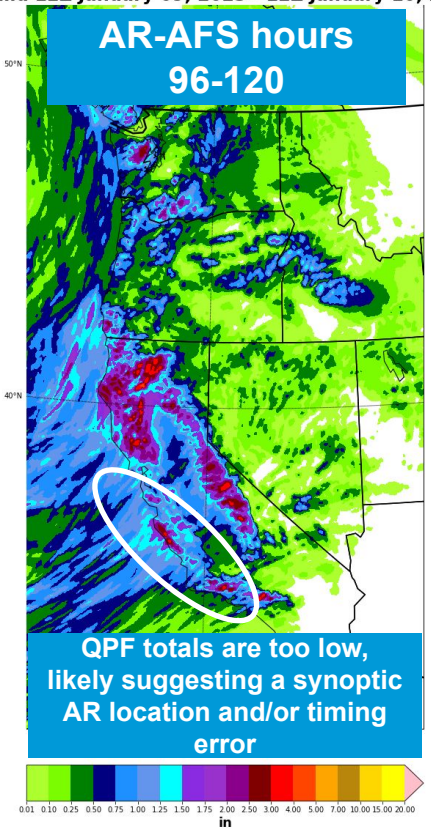
URMA 2.5km 24 HR QPE Valid
12Z January 09, 2023 - 12Z January 10, 2023



12Z ARAFS Day 1 (f024) 24 HR QPF
Valid 12Z January 09, 2023 - 12Z January 10, 2023

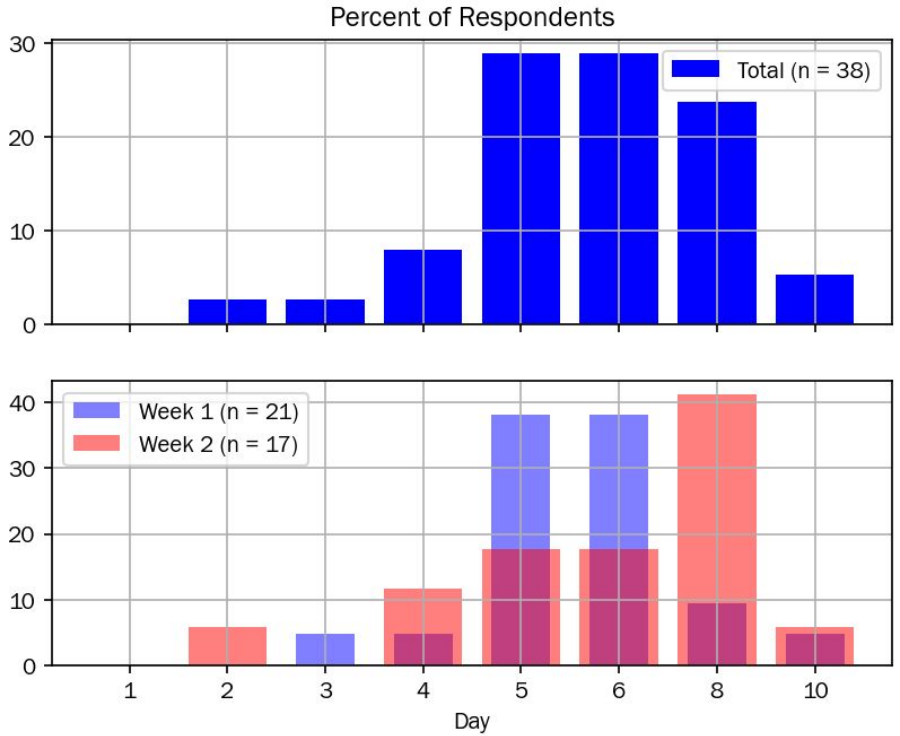


12Z ARAFS Day 5 (f120) 24 HR QPF
Valid 12Z January 09, 2023 - 12Z January 10, 2023



Preliminary PEAR 2024 Results

“I get concerned about an AR event at day __ lead time”



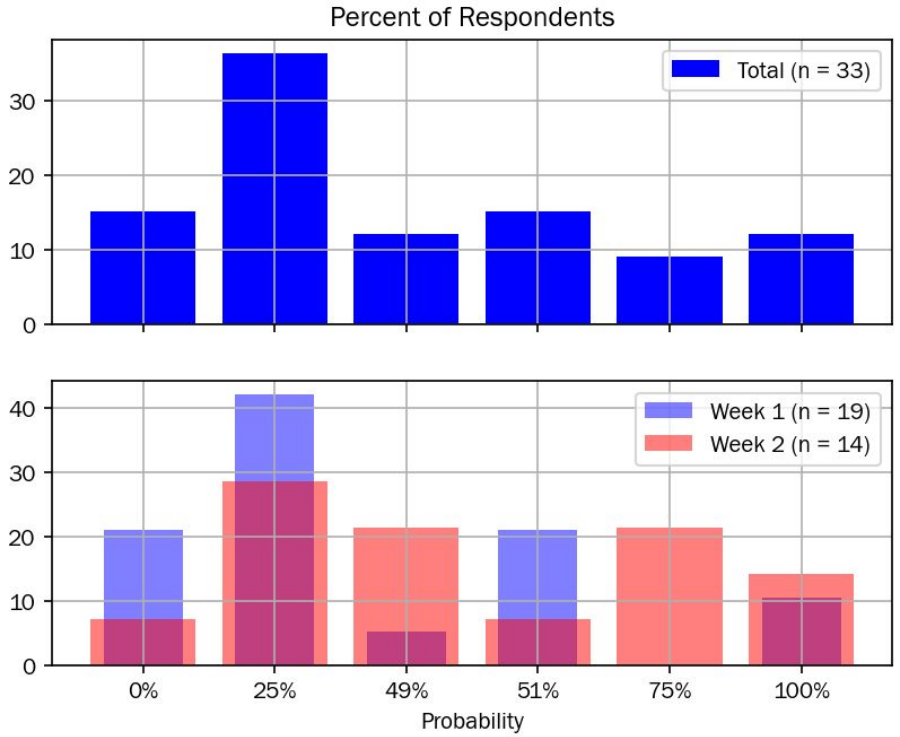
“Shocking number of partners make [decisions at] lead times longer than I envisioned”

Paraphrase: Southeast AK depends on vessels for commerce and supplies, and is not on the AK highway system. Long lead time helps to prepare

“Many people have a regular weekend … we start messaging before the weekend in case people don’t receive that message”

Preliminary PEAR 2024 Results

“How likely are you to start to use CAMs to forecast ARs at day 6 lead time?”



“If it’s just deterministic, [it starts] to diverge from ensemble means. Pulls us into erroneous solutions”

“I wouldn’t want to start messaging too early and then have to backtrack that”

“I would think of it more as another tool in the toolbox… just like any other model, you can’t take everything at face value but it’s not bad to have”

“When I hear about adding new tools to the toolbox, it makes me worried because we already have too many. At what point is it too much”

Preliminary PEAR 2024 Results

Focus Group Highlights:

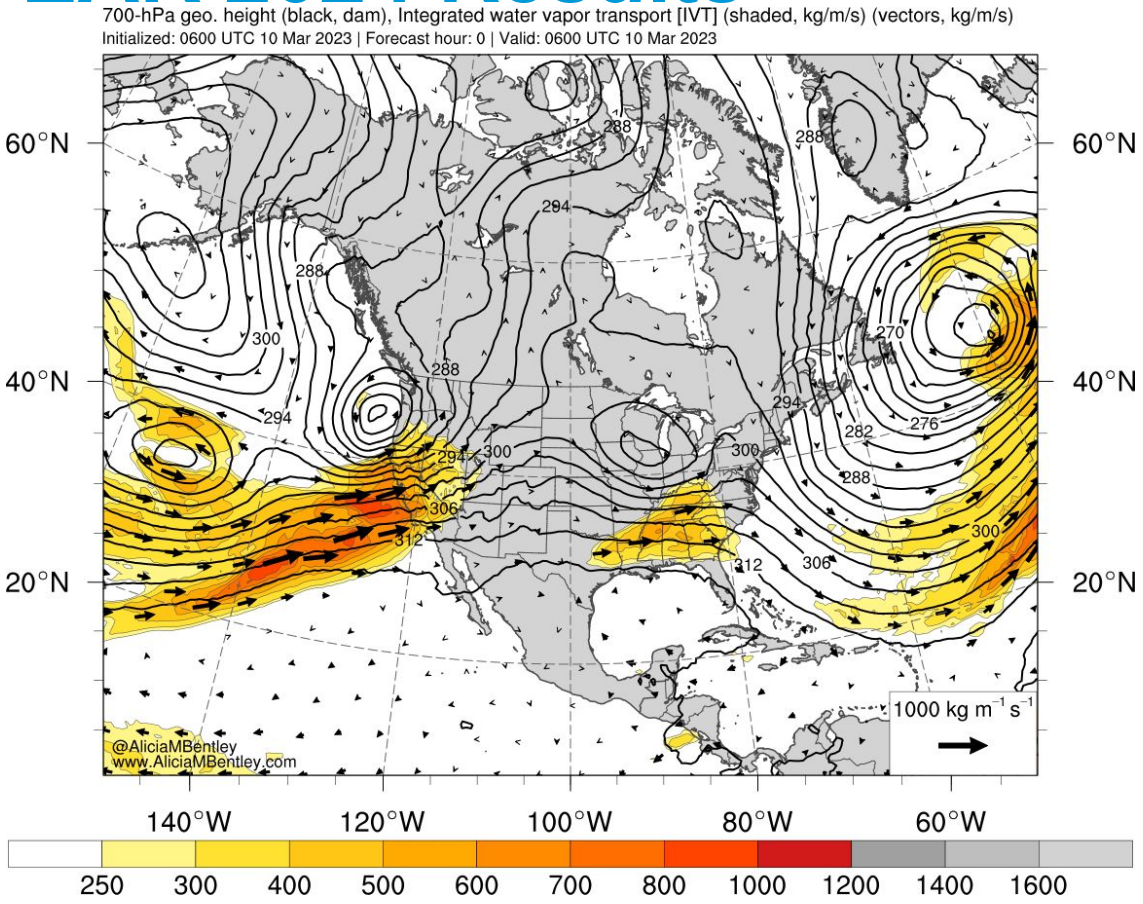
- AR orientation is important for forecasting precipitation impacts around complex terrain
- IVT is valued more than PWAT for forecasting ARs. Example quote: “PWAT is taking out the wind. Not getting as much of the picture. You can have all the PWAT … it won’t lead to precip amounts”
- Precipitation rates and duration that matter vary depending on geography, burn scars, etc.
- Many participants prefer ensembles at medium range lead times for forecasting ARs

Preliminary PEAR 2024 Results

06 UTC 10 Mar 2023
GFS Analysis

Major AR approaching the US West Coast associated with the interaction of two upper-level troughs

Broad IVT plume makes landfall in California

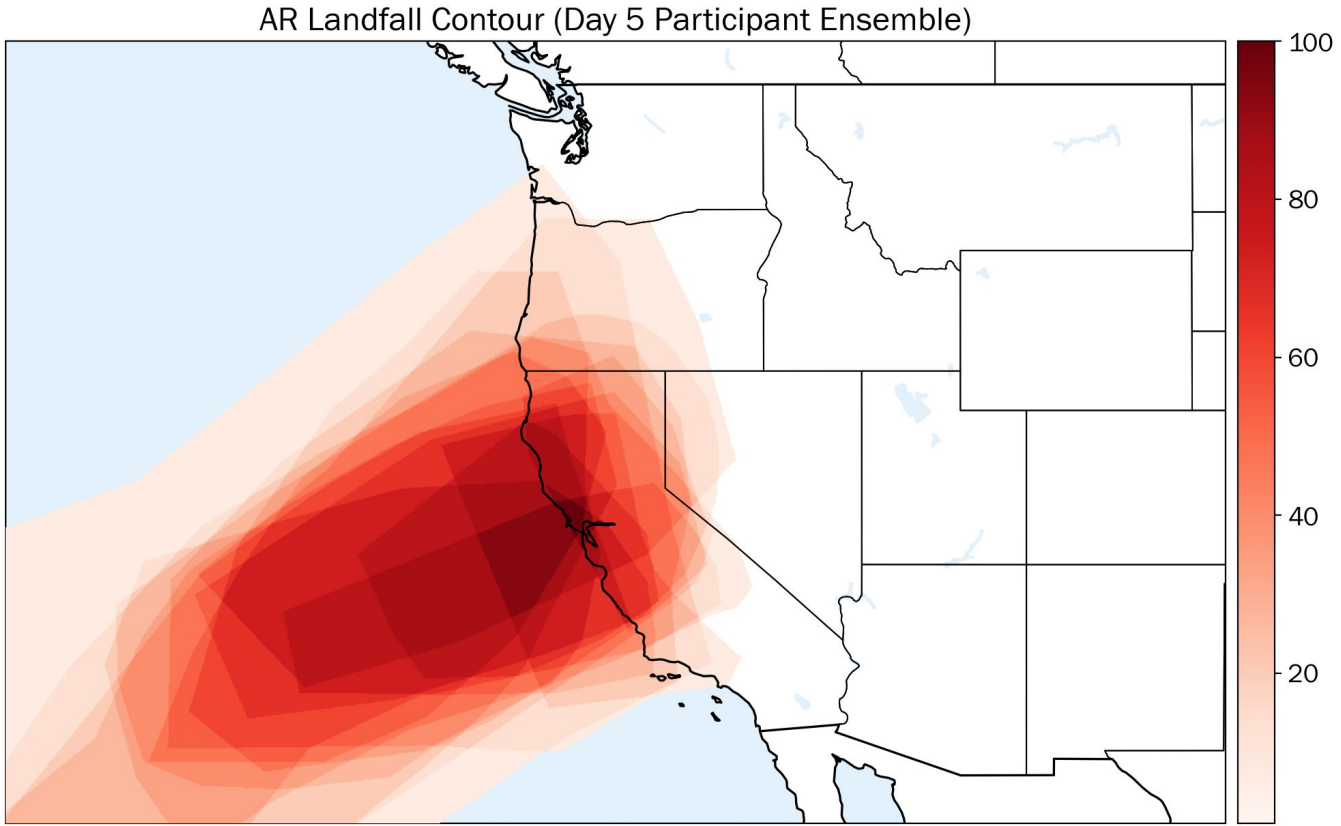


Preliminary PEAR 2024 Results

9–10 Mar 2023
Day 5

“I was pretty broad with my contour because of the model spread”

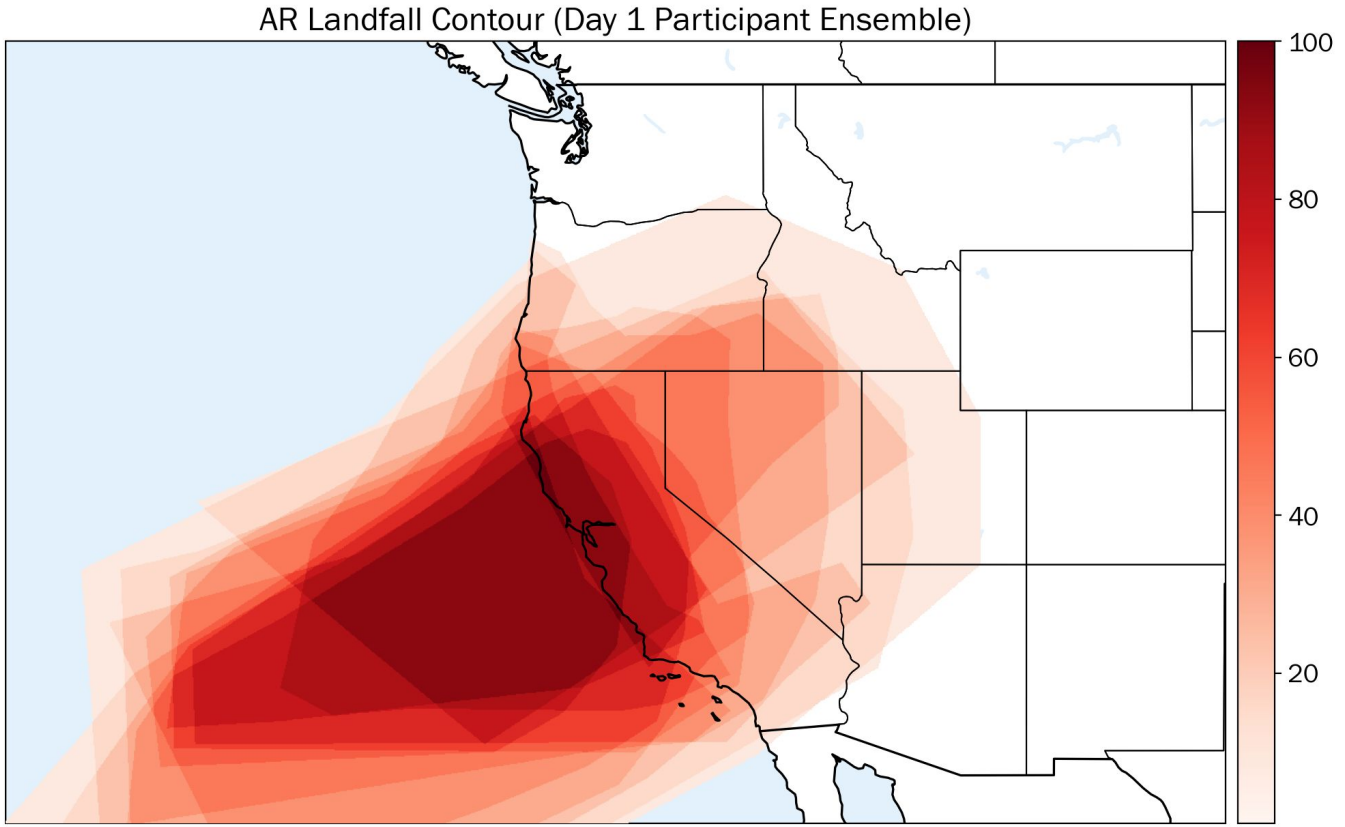
“I used a combo of 250 IVT and precipitation amounts and rates”



Preliminary PEAR 2024 Results

9–10 Mar 2023
Day 1

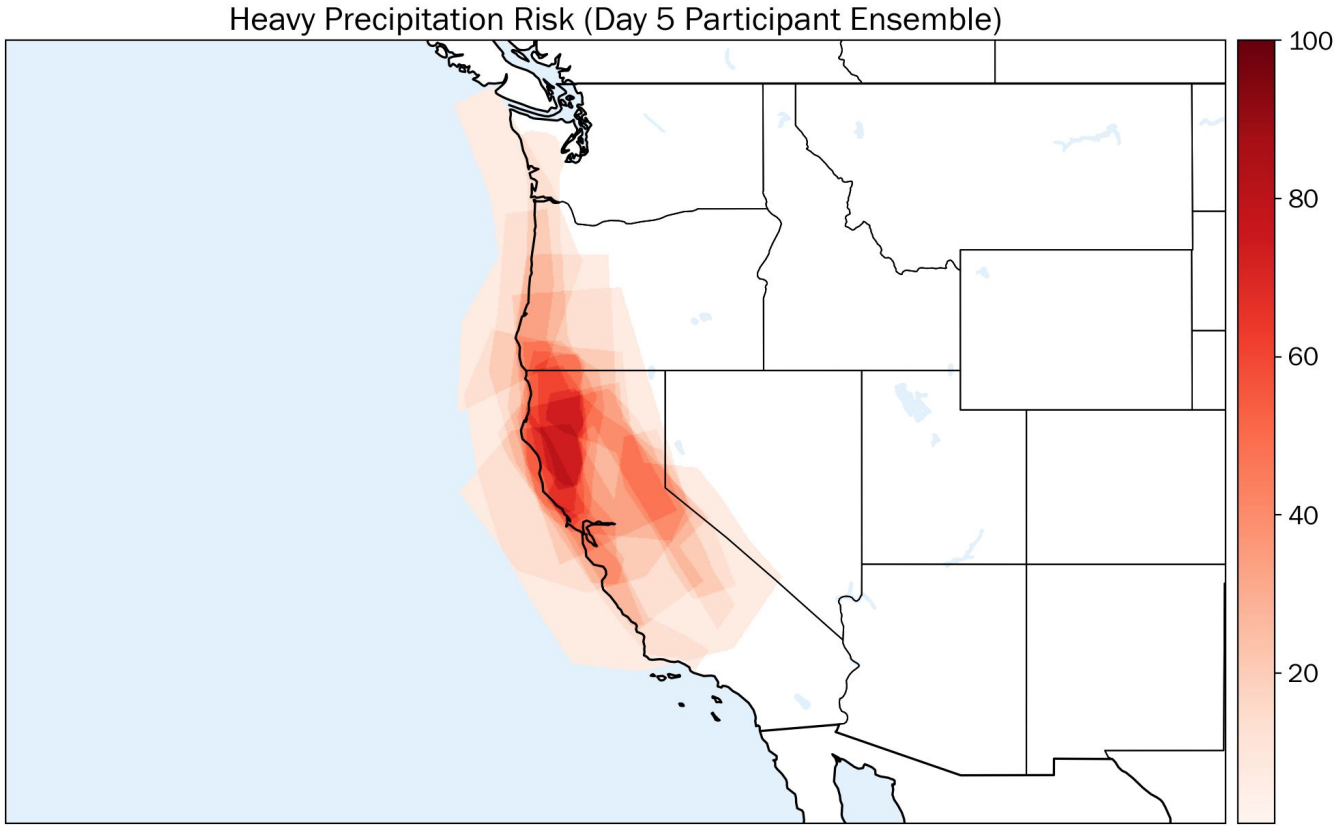
“It was pretty broad for an IVT plume and for me I treated it like a weighted average”



Preliminary PEAR 2024 Results

9–10 Mar 2023
Day 5

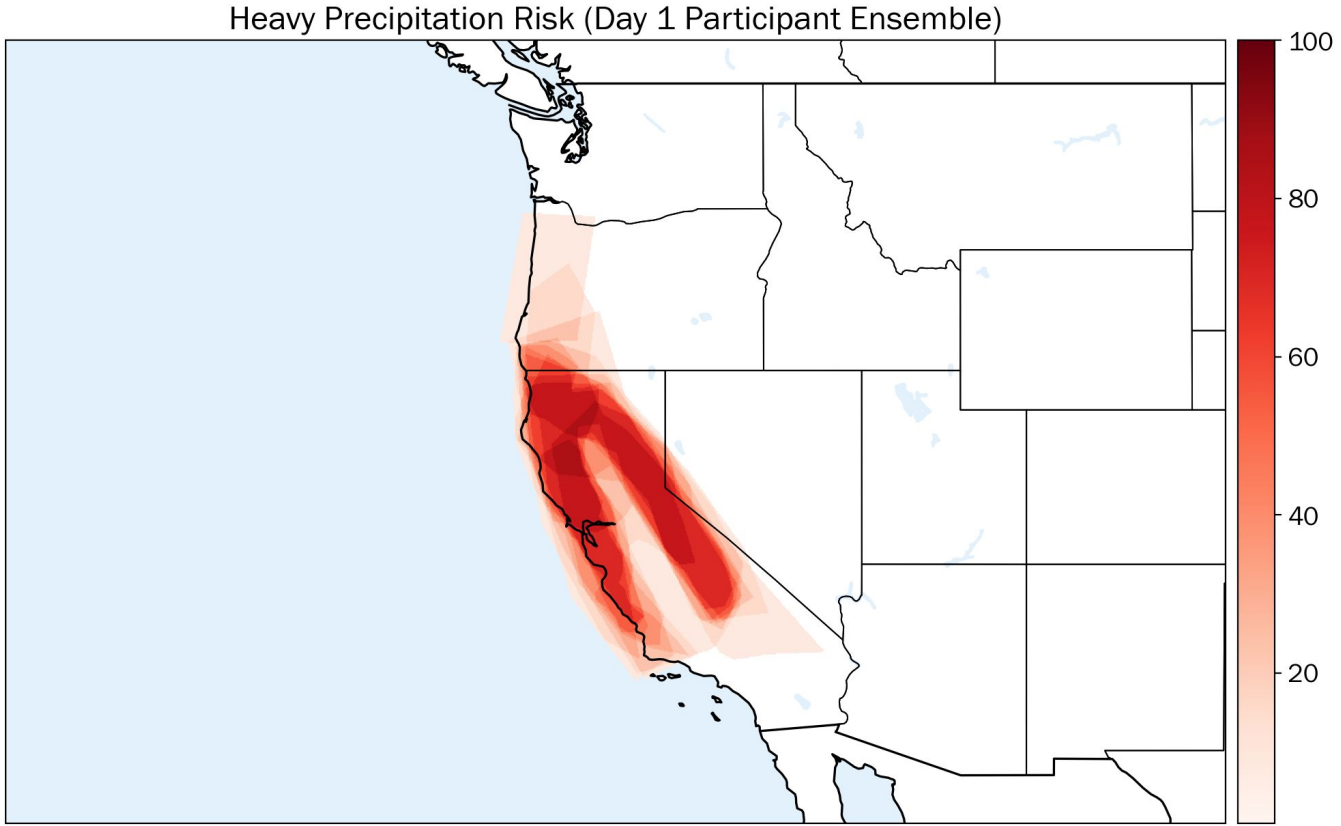
“For heavy precip risk in particular I was more conservative with how much I drew and I kind of focused on the NW CA area where the focus is. I think that’s because I know that when I forecast at these lead times, I can always expand that later”



Preliminary PEAR 2024 Results

9–10 Mar 2023
Day 1

Participants noted having more information (i.e., ensembles) would have helped to make a more educated guess



Preliminary PEAR 2024 Results

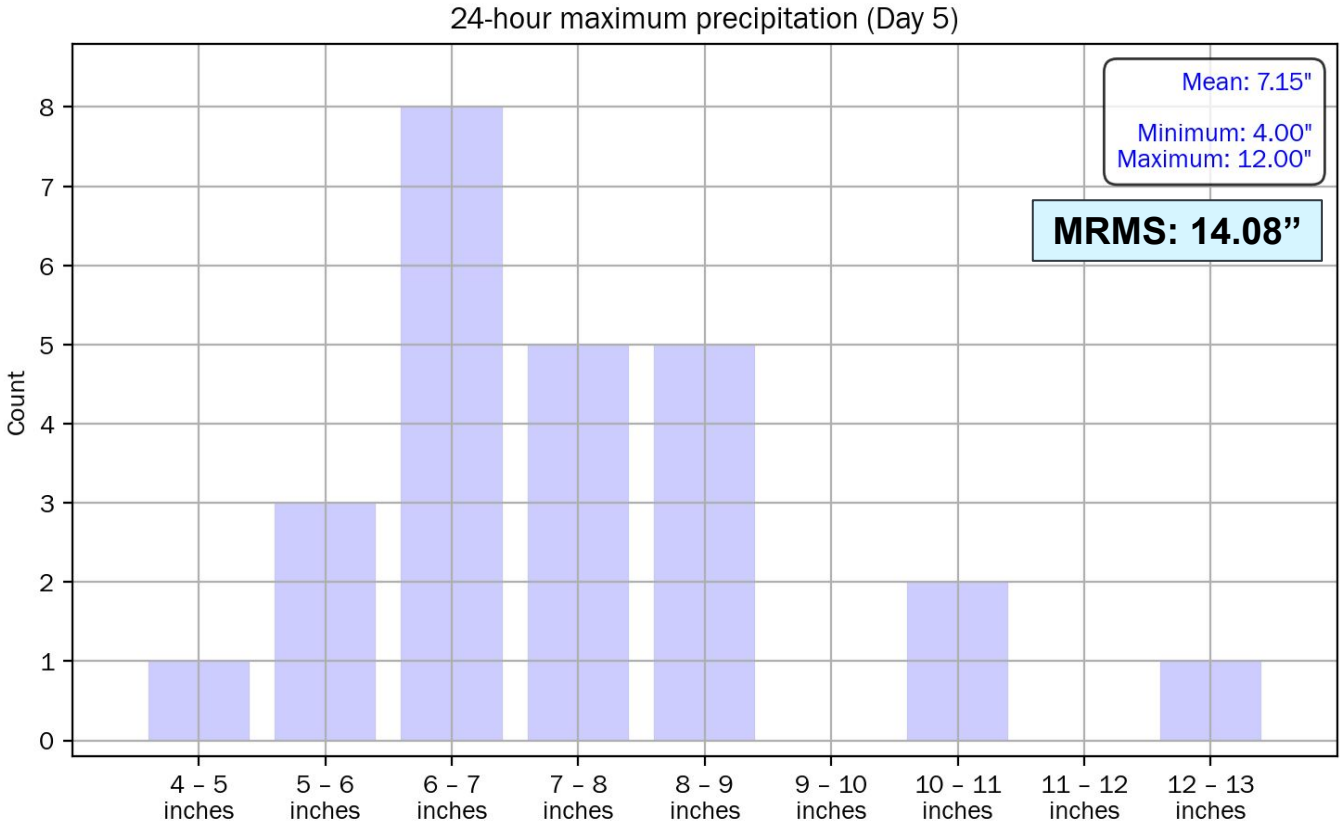
- Now that we've looked at the spatial distribution of participant forecasts… what about quantitative forecasts?
- Precipitation extreme forecasting is an important component to IDSS and communicating impacts
- Participants were tasked with forecasting the maximum 24-hour and 6-hour precipitation in the domain of interest (US West Coast) given available model guidance
- Participants were given a 24-hour window (12 UTC to 12 UTC) to forecast the maximum precipitation amount during that window

Preliminary PEAR 2024 Results

9–10 Jan 2023
Day 5

Max 24-hour QPF

The CAM plots made available to participants (AR-AFS, West-WRF) only covered half of the 24-hour forecast period at this lead time

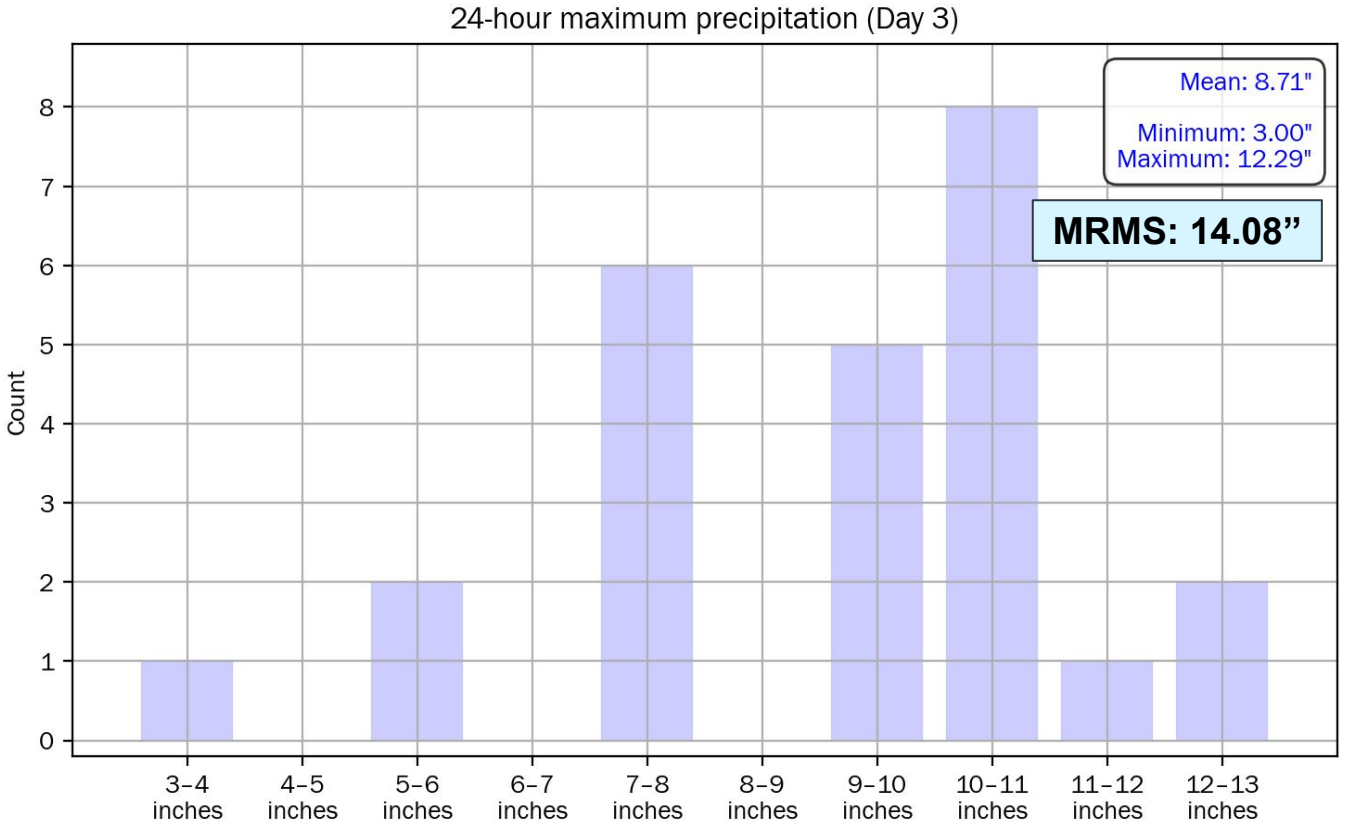


Preliminary PEAR 2024 Results

9–10 Jan 2023
Day 3

Max 24-hour QPF

AR-AFS and West-WRF were fully available for participants – even so, the domain maximum 24-hour precipitation total was underestimated

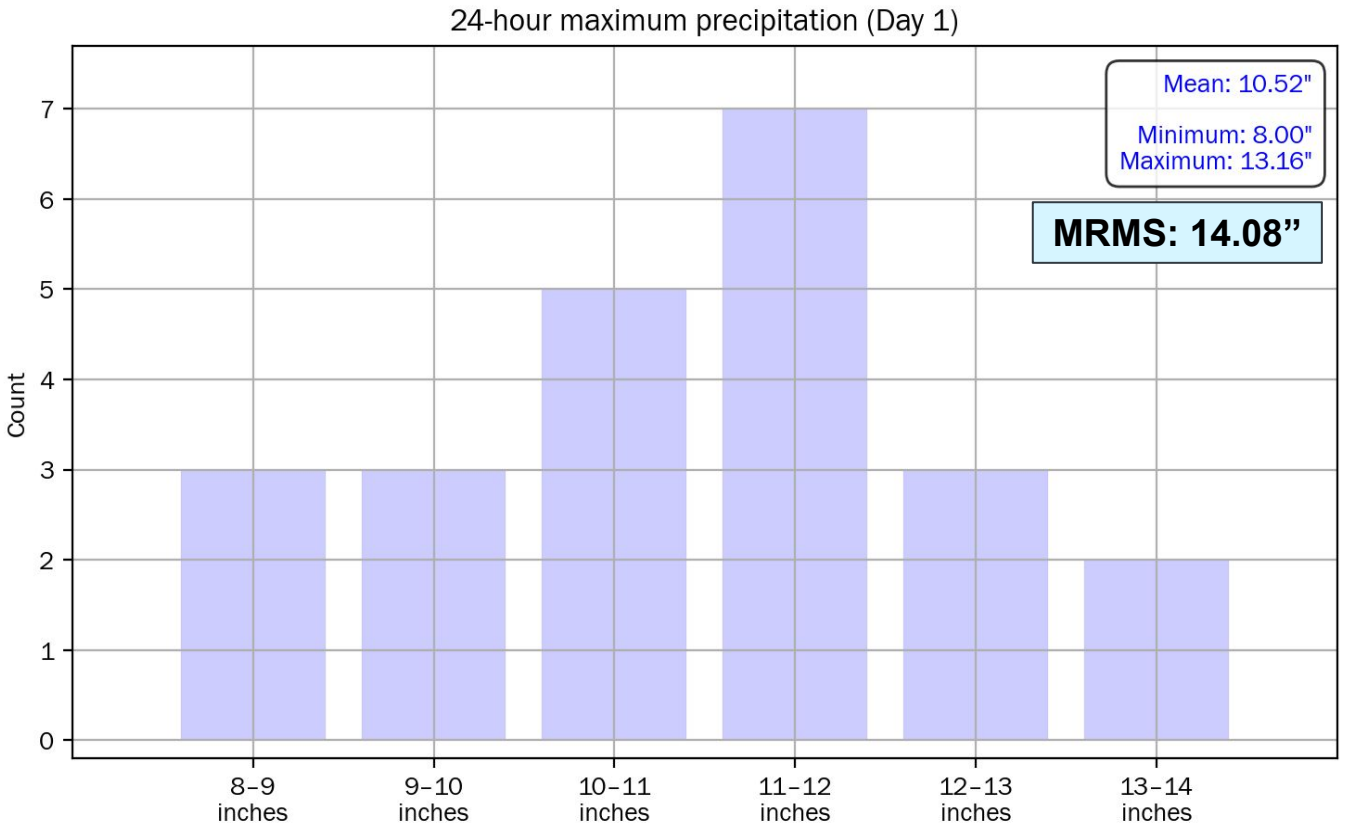


Preliminary PEAR 2024 Results

9–10 Jan 2023 Day 1

Max 24-hour QPF

Even with the addition of the UFS-AR at day 1 lead time, participants still underestimated the maximum domain 24-hour precipitation total

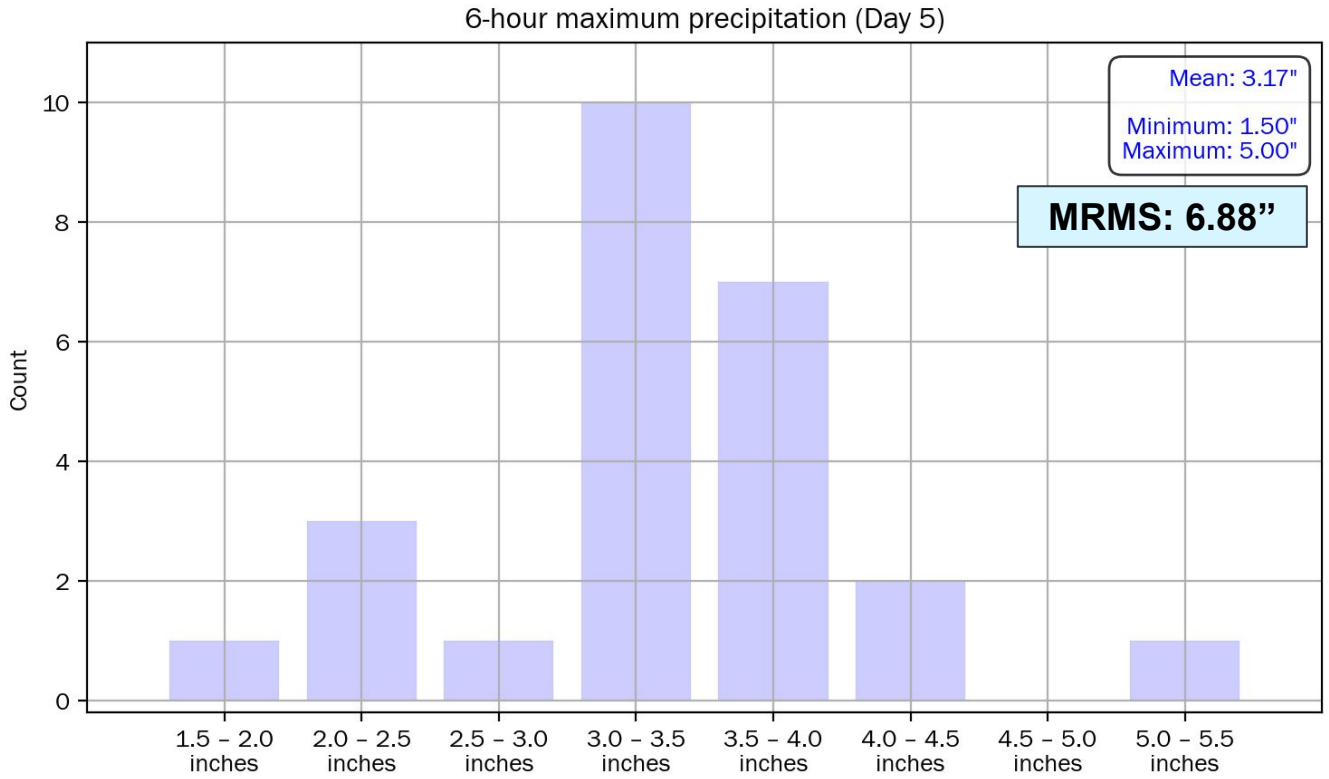


Preliminary PEAR 2024 Results

9–10 Jan 2023
Day 5

Max 6-hour QPF

Participants vastly underestimated the actual maximum 6-hour precipitation

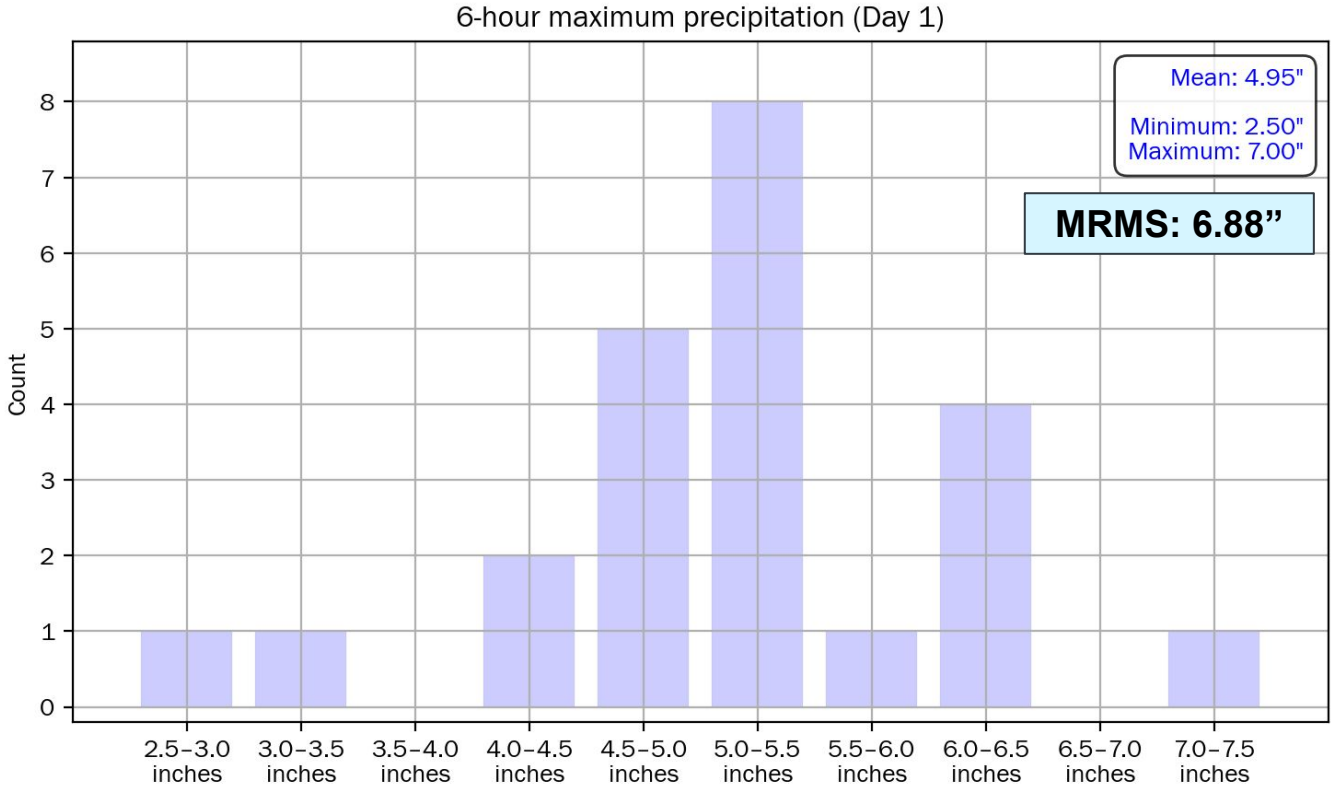


Preliminary PEAR 2024 Results

9–10 Jan 2023
Day 1

Max 6-hour QPF

Forecasts trended higher at day 1 lead time, but still underestimated the maximum 6-hour precipitation



Future Goals

- Continue to build the PEAR experiment:
  - Develop forecast and evaluation activities that allow forecasters to contribute feedback to model developers
  - Incorporate more IDSS-related activities where participants make use of the experimental models
- Expand PEAR to include additional experimental models, including AI models, and more retrospective cases for medium-range forecasting
- Evaluate usefulness of satellite and AR-recon data in situational awareness and forecasting AR impacts