Characterizing Warm-Season Extreme Precipitation in the HREF means

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Introduction

Extreme Precipitation from warm-season convection is one of the most challenging weather phenomena to forecast yet oftentimes can be the most impactful. Flash-flooding and mudslides are just a few of the impacts that can be detrimental to life and property when an extreme precipitation event occurs.

Accurate forecasts of warm-season extreme precipitation require high-resolution, convective allowing models (CAMS) to capture the small-scale processes that lead to extreme precipitation rates. The NCEP High Resolution Ensemble Forecast system (HREF) is an ensemble of CAMS that has the ability to give a range of possible outcomes and probabilistic information that cannot be provided by deterministic CAMS alone.

Ensemble means are a commonly used as a starting point in forecasting to characterize model agreement but can smooth out high-amplitude features and increase the spread of low-amplitude features, giving a poor representation of extreme precipitation. Probability-matched means (PMM) improve retention of local convective structures by replacing the ensemble mean amounts with amounts sampled from the distribution of ensemble member forecasts. The PMM has been found to be more skillful than the individual members and the ensemble mean when forecasting precipitation.

This study assess the performance of the PMM, the local PMM (LPMM) and arithmetic mean from the HREF during the summer months (June, July, and August) of 2021 and 2022 when the ensemble membership remained fixed. **This evaluation will provide forecasters with contextual information to help increase confidence, situational awareness, and skill when using the HREF means to forecast extreme precipitation events.**

Data and Methods

HREF Quantitative Precipitation Forecasts (QPF)

- Forecasts for lead times 0–48 h
- ~3 km grid spacing
- 1-hourly temporal resolution

Configuration period: 2021-05-11 through present

Member	ICs	LBCs	Microphysics	PBL	dx (km)	Vert. levels	Included in HREF hours
HRRR	RAP -1h	RAP -1h	Thompson	MYNN	3.0	50	0 - 36
HRRR -6h	RAP -1h	RAP -1h	Thompson	MYNN	3.0	50	0 - 30
HRW ARW	RAP	GFS -6h	WSM6	YSU	3.2	50	0 - 48
HRW ARW -12h	RAP	GFS -6h	WSM6	YSU	3.2	50	0 - 36
HRW FV3	GFS -6h	GFS -6h	GFDL	GFS EDMF	3.0	60	0 - 60
HRW FV3 -12h	GFS -6h	GFS -6h	GFDL	GFS EDMF	3.0	60	0 - 48
HRW NSSL	NAM	NAM -6h	WSM6	MYJ	3.2	40	0 - 48
HRW NSSL -12h	NAM	NAM -6h	WSM6	MYJ	3.2	40	0 - 36
NAM CONUS Nest	NAM	NAM	Ferrier-Aligo	MYJ	3.0	60	0 - 48
NAM CONUS Nest -12h	NAM	NAM	Ferrier-Aligo	MYJ	3.0	60	0 - 48

Source: https://www.spc.noaa.gov/exper/href/#

Multi-Radar Multi-Sensor Pass 2 (MRMS) Quantitative Precipitation Estimates (QPE)

- 1-km grid spacing
  - The MRMS is regridded to the HREF grid using Earth System Modeling Framework's bilinear interpolation
- 2-minute temporal resolution
  - The MRMS is accumulated to 1-hourly amounts

A frequency analysis on 1-hourly precipitation is performed over the contiguous US. The QPE is compared to the ensemble QPF for the following variables:

Mean → amount of precipitation at each grid point is the average of all members.

PMM → computed by allowing all points in the computational domain to participate in reassignment. Grid point values from individual members could be reassigned to very different geographic locations in the PM mean.

LPMM → the PMM that only considers the distribution of ensemble member precipitation amounts within a specified radius of influence.

<u>Characterization of 1-hourly Extreme Precipitation</u>

1 in
2-yr Average Recurrence Interval (ARI)
100-yr ARI (top 1% events)

*The ARI is the expected amount of time between precipitation exceedances of a specific magnitude. It is calibrated toward the climatology of a given point.

Preliminary Results

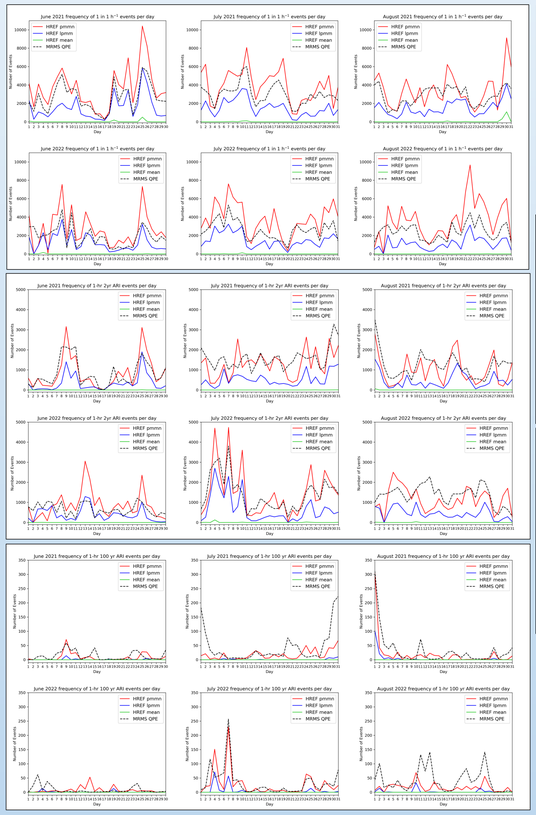

Figure 1: Daily frequency of hourly 1-in, 2-yr ARI, and 100-yr ARI exceedances for June, July, and August in 2021 and 2022 over entire US.

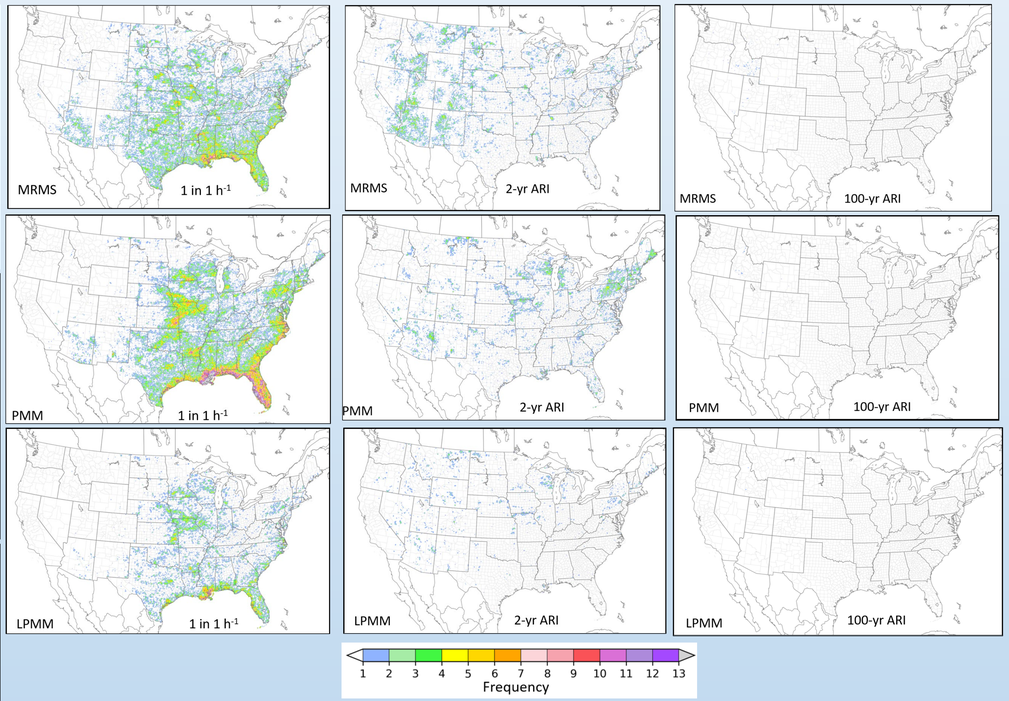

Figure 2: Spatial representation of the frequency of hourly 1-in, 2-yr ARI, and 100-yr ARI exceedances summed over June, July, and August during 2021.

- The arithmetic mean gives a poor representative of summertime extreme rainfall.
- PMM generally over forecasts the 1 in frequency observed by the MRMS and LPMM under forecasts the 1 in frequency observed by the MRMS.

- Most 1-in exceedances occur in the eastern US. PMM over forecasts in the eastern US and under forecasts in the western US. LPMM sometimes has better regional representation of 1-in exceedances (e.g., Louisiana in 2021).
- CONUS-wide, PMM over forecasts the 2-yr ARI exceedances observed by the MRMS, but sometimes the events are well forecasted or under forecasted. PMM over forecasts 2-yr ARI exceedances in the eastern US and under forecasts in the western US.
- The LPMM generally under forecasts the frequency of 2-yr ARI exceedances.
- 100-yr ARI exceedances all occur in the western US and are under forecasted by both PMM and LPMM (e.g., Idaho in 2021).

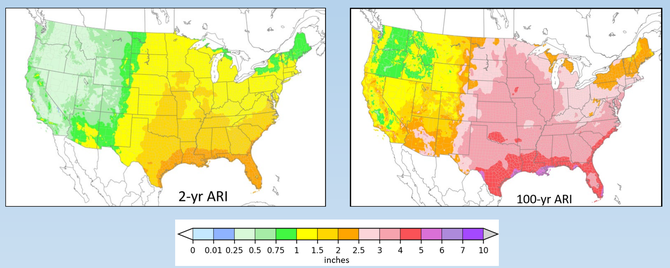

Figure 3: Precipitation values associated with the 2-yr ARI and 100-yr ARI for the 1-hour duration from the NOAA Atlas-14.

Future Work

- Comparison to other durations (i.e., 3- and 6-hourly).
- Critical Success Index and Fractional Skill score to quantify regional skill.
- Event-based analysis → understand the precipitation systems where PMM and LPMM are most skillful (i.e., tropical cyclones vs. monsoon).
- Comparison with individual members and ensemble percentile amounts (i.e., 50th and 90th percentiles).