Updating Intensity-Duration-Frequency (IDF) Curves for Sub-Daily Precipitation Events under CMIP6 Climate Change Scenarios: The Case of Pensacola and Perdido Bays Watersheds

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Background

Image Source: https://sitn.hms.harvard.edu/flash/2022/climate-change-is-happening-in-our-own-backyards/

Intensity-Duration-Frequency (IDF) Curves

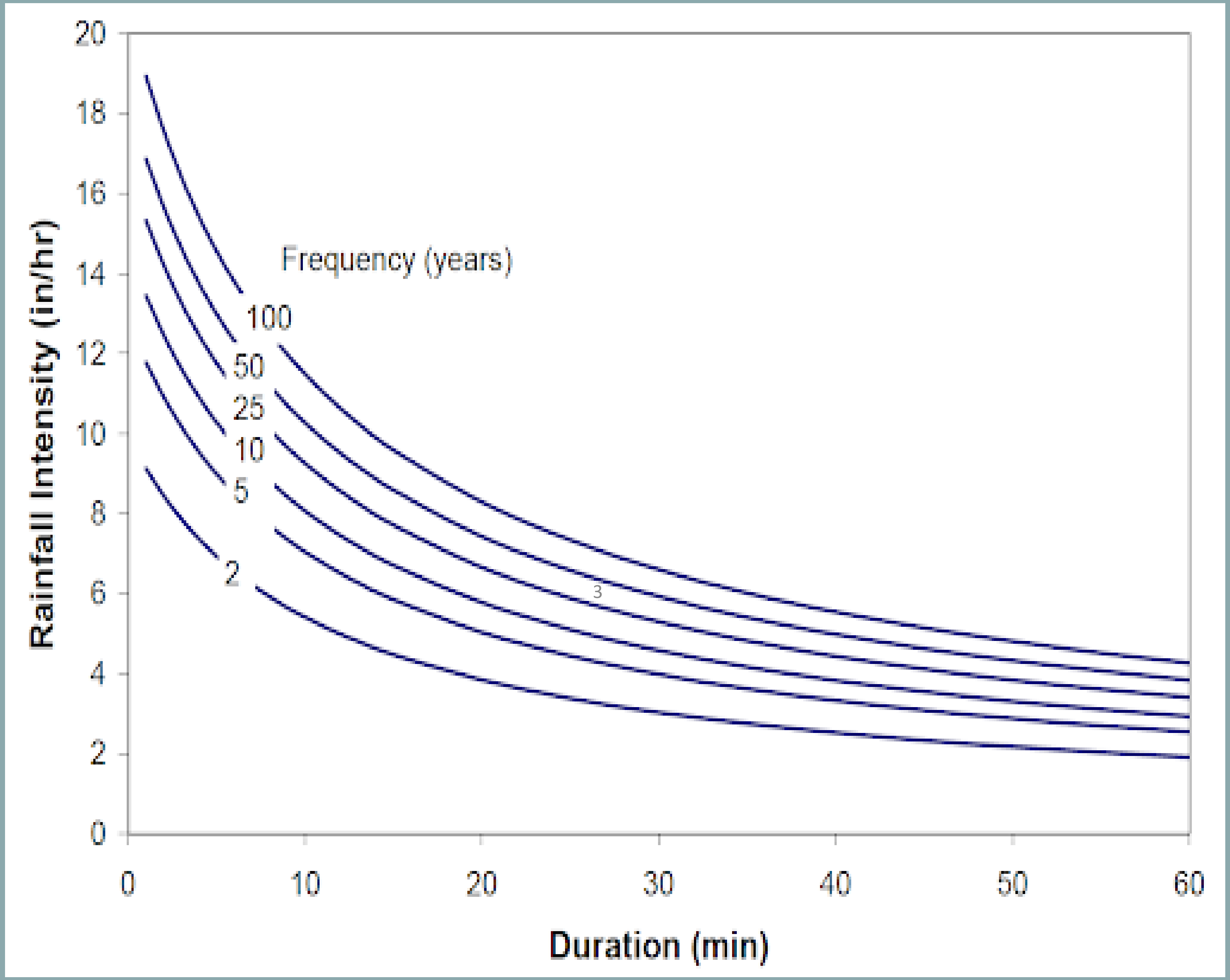

Image Source: https://www.researchgate.net/publication/228834807_Synthesis_of_Storm_Drainage_Design

Why Updating IDF Curves?

- Climate change: Precipitation events

- Operation rules of regulating hydraulic infrastructure

- Flood mitigation strategies

- Climate change adaptation

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Image Source: https://www.bbc.co.uk/newsround/53595703

Objectives

- To derive historical IDF curves for sub-daily precipitation.
- To bias correct global climate models (GCMs): High quantiles.
- To derive future precipitation time series at sub-daily timescale.
- To derive future IDF curves.

Study Area

Pensacola and Perdido Bays Watersheds

- Contains 2 HUC8 watersheds.
- Susceptible to heavy floods and sea level rise.
- Experienced at least 4 category Hurricanes within last 20 years (Ian, Michael, Katrina and Ivan).

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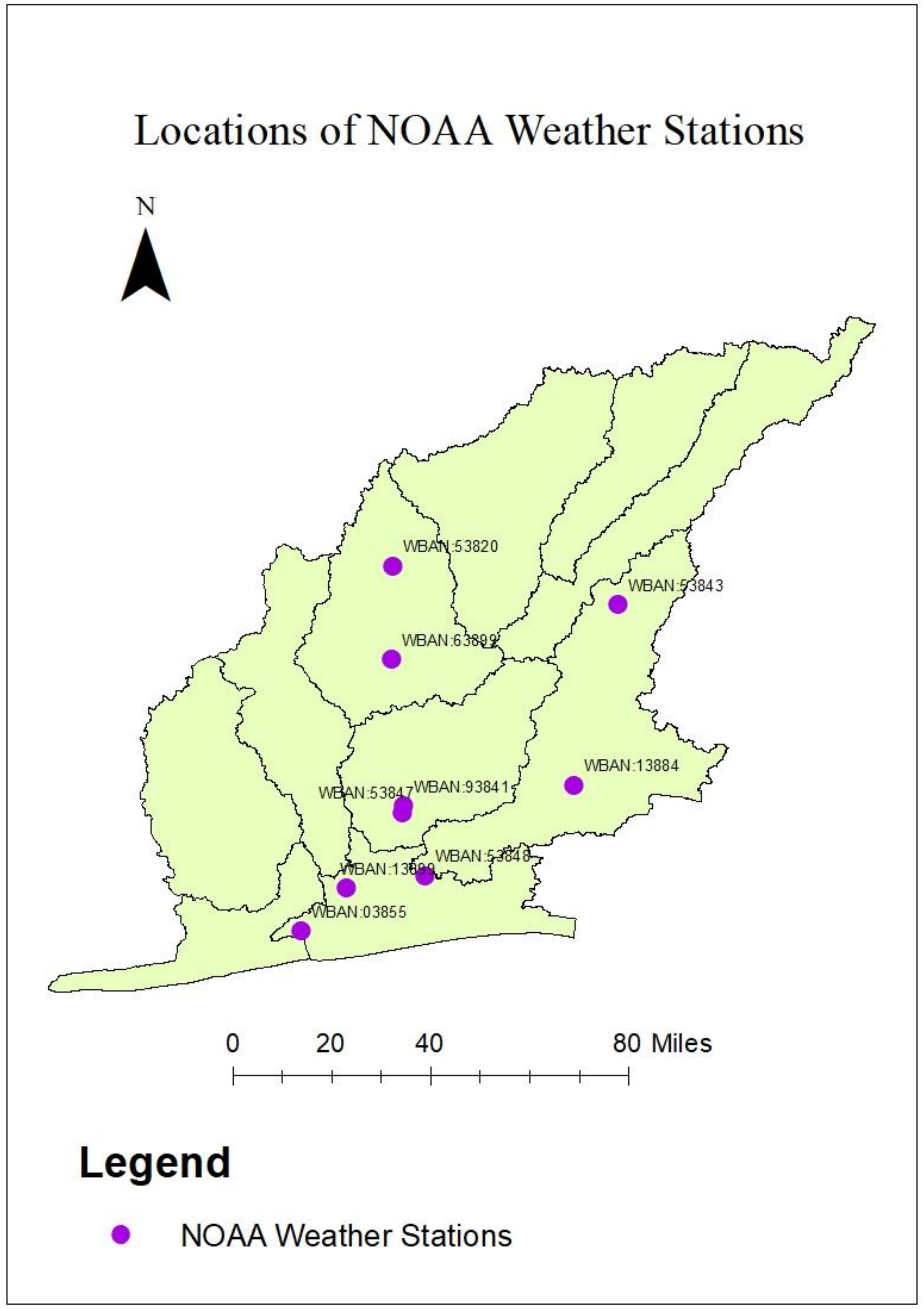
Data Collection and Processing

- Hourly data collected from NOAA NCEI (2007-2022).
- 9 weather stations.
- Different durations from hourly to 3 days (1, 2, 3, 6, 12, 18, 24, 48 and 72 hours).
- Annual maximum precipitation.



Fitting Probability Distributions

- Generalized Extreme Value (GEV) distribution with a Maximum Likelihood (MLE) parameter estimation

- IDF curves derived based on the quantiles of different durations and return periods

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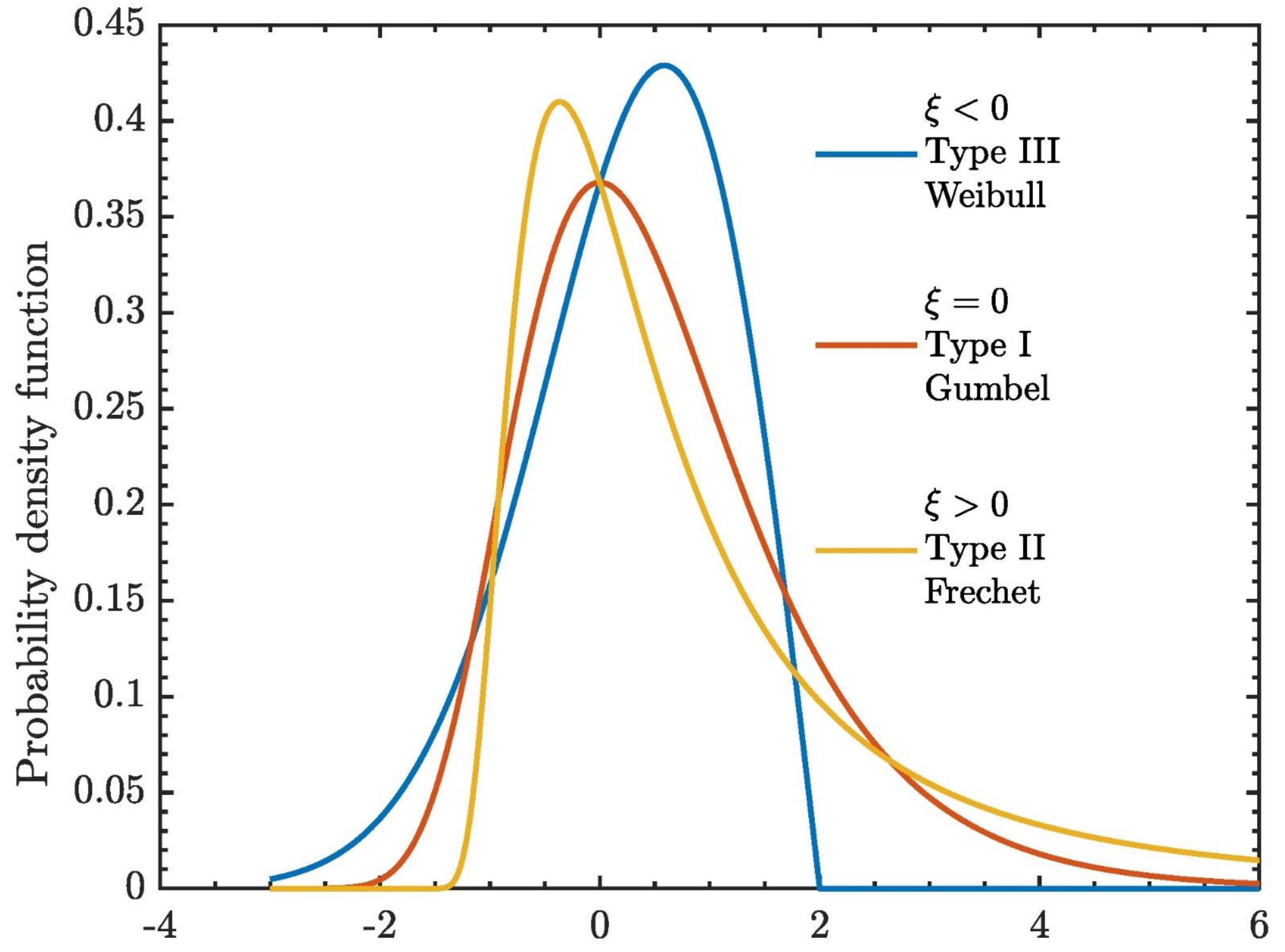
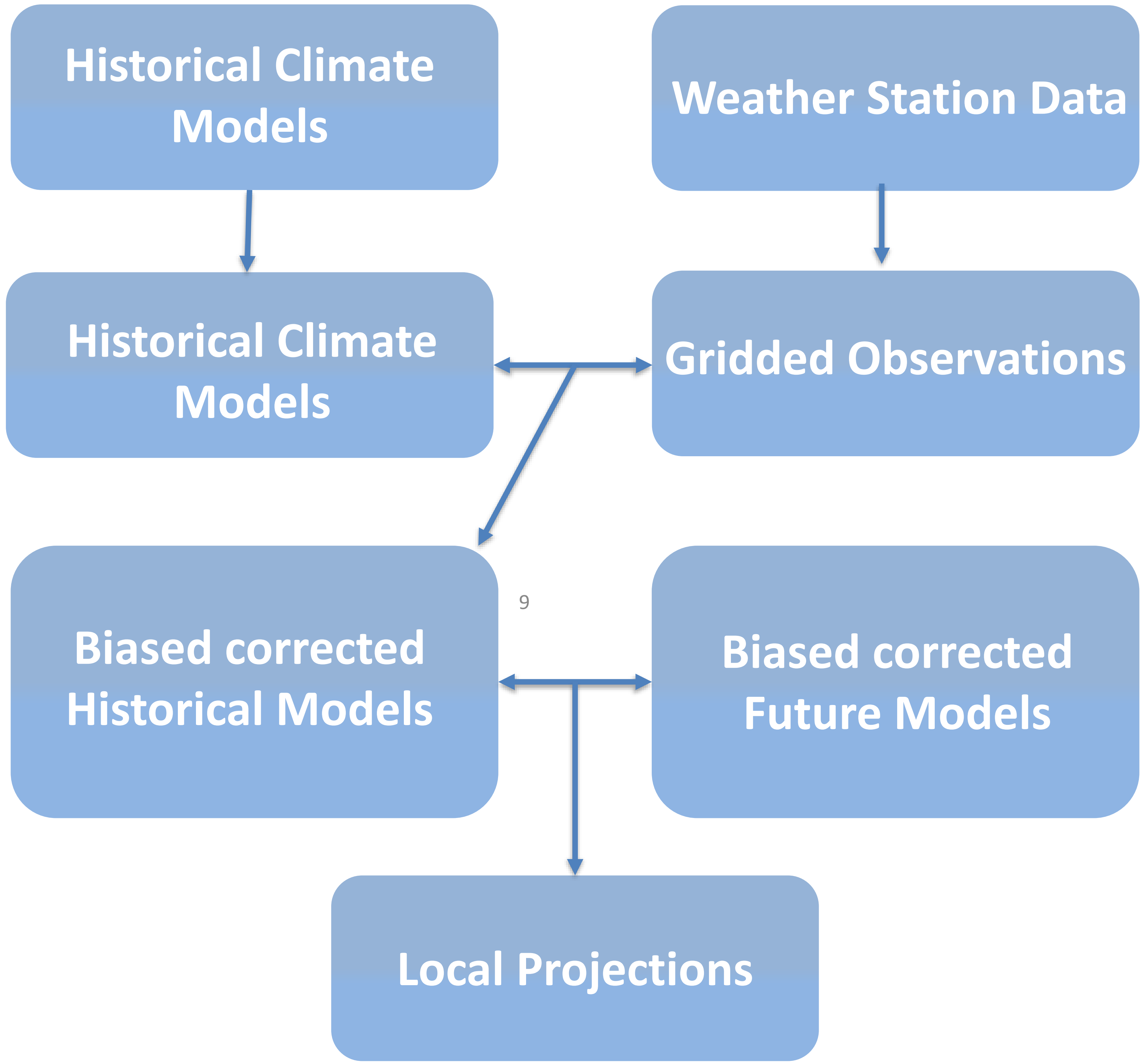


Methodological Flow Chart



Global Climate Model (GCM)

- Community Earth System Model 2 (CESM2) developed by NCAR is selected.
- GCM selected containing daily precipitation.
- Climate scenario SSP585 of the Coupled Model Intercomparison Project Phase 6 (CMIP6) is considered.

Bias correction of GCM Outputs

- Standard Empirical Quantile Mapping (EQM) and EQM with a linear correction for upper quantiles (EQM-LIN)

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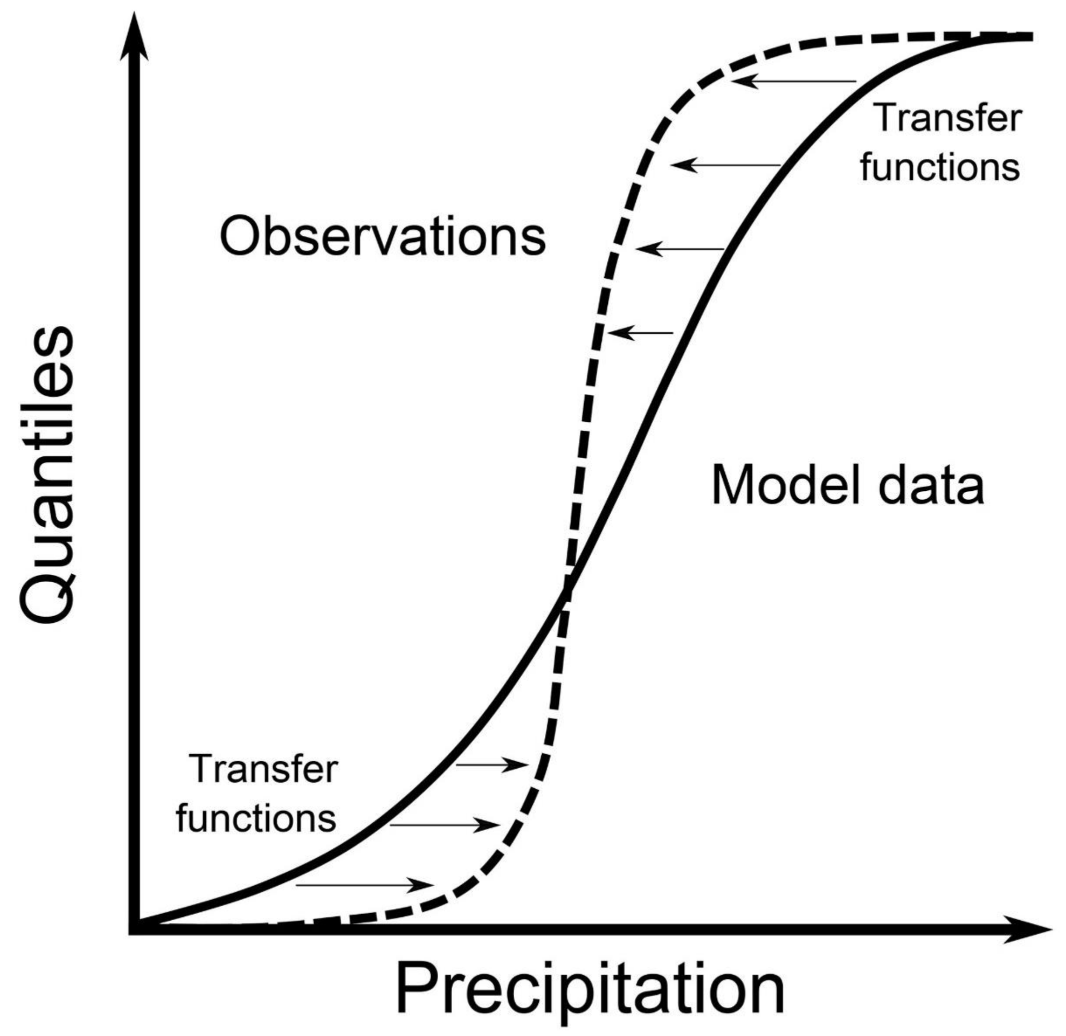
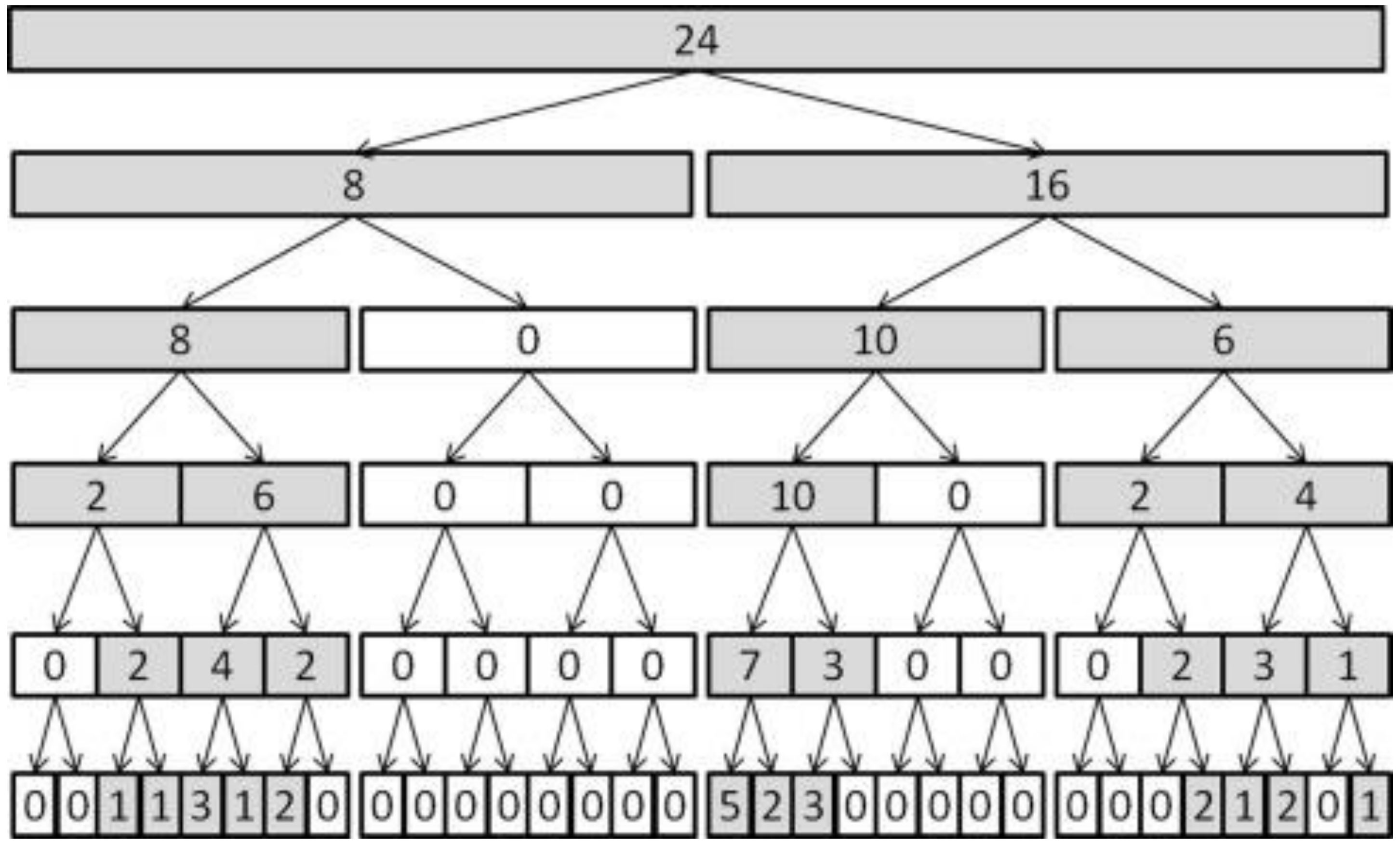
- Bias corrected model outputs for future projection



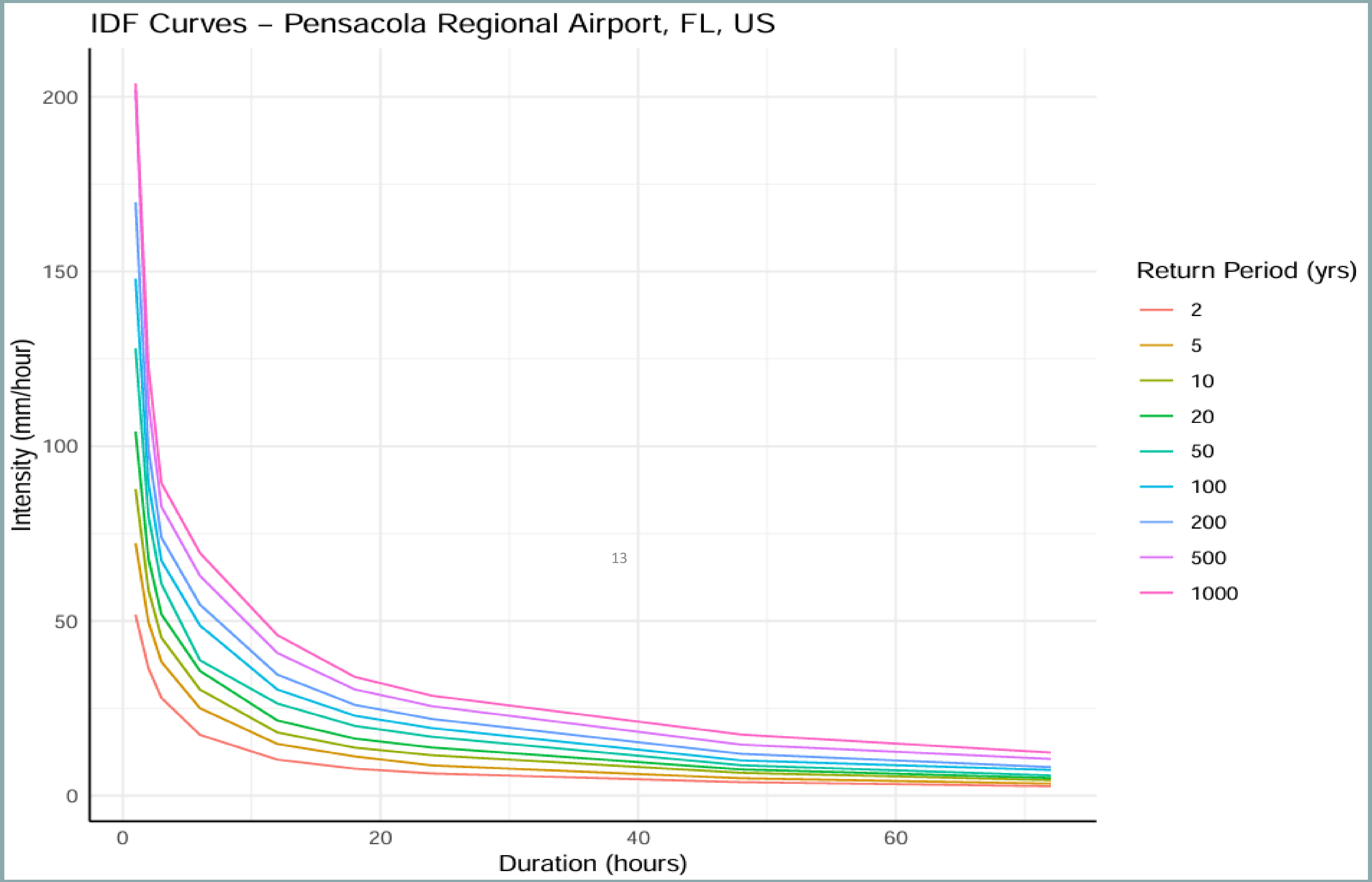
Temporal Disaggregation

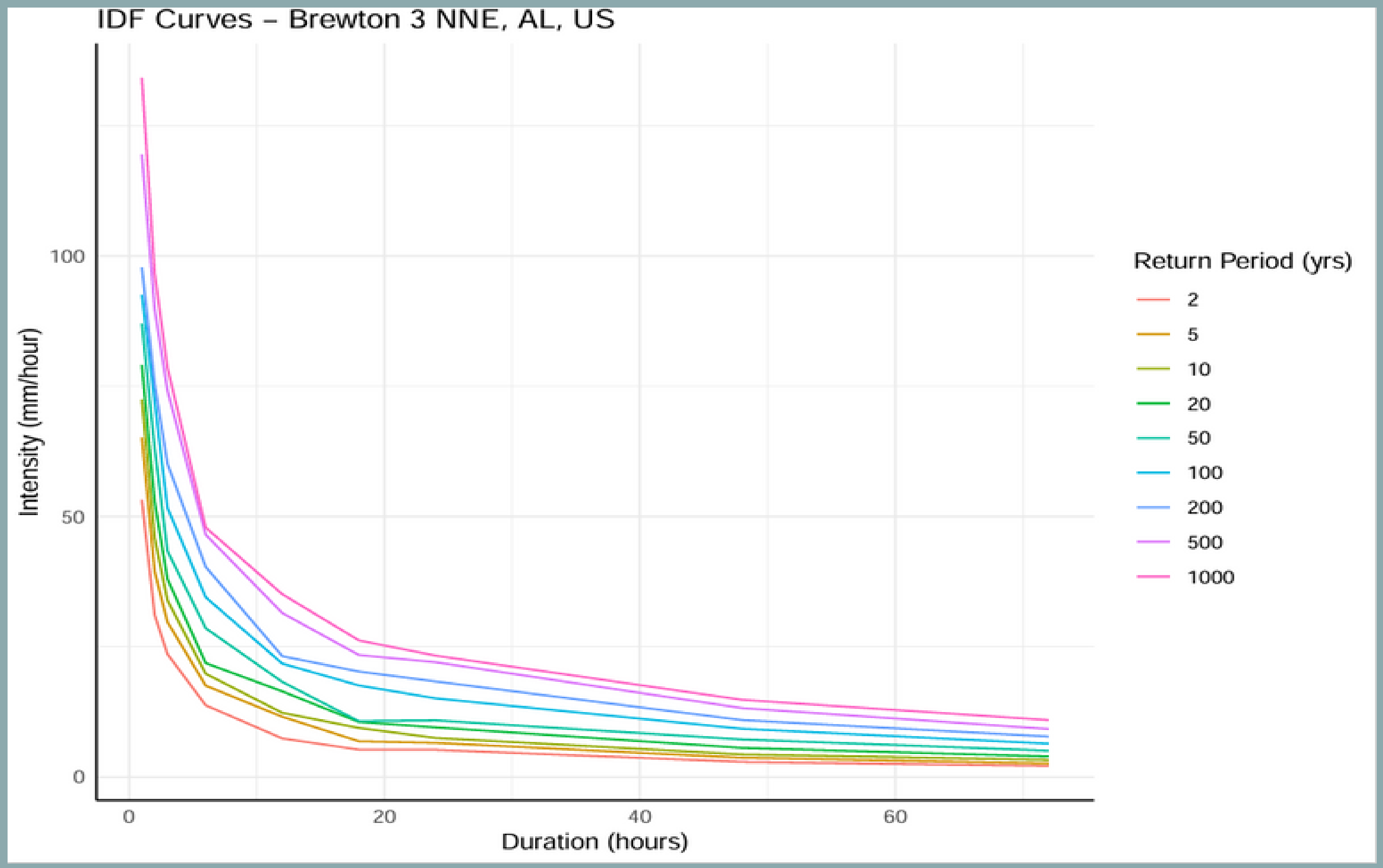
- Bias corrected daily precipitation were disaggregated into hourly data by continuous deterministic approach using NetSTORM.

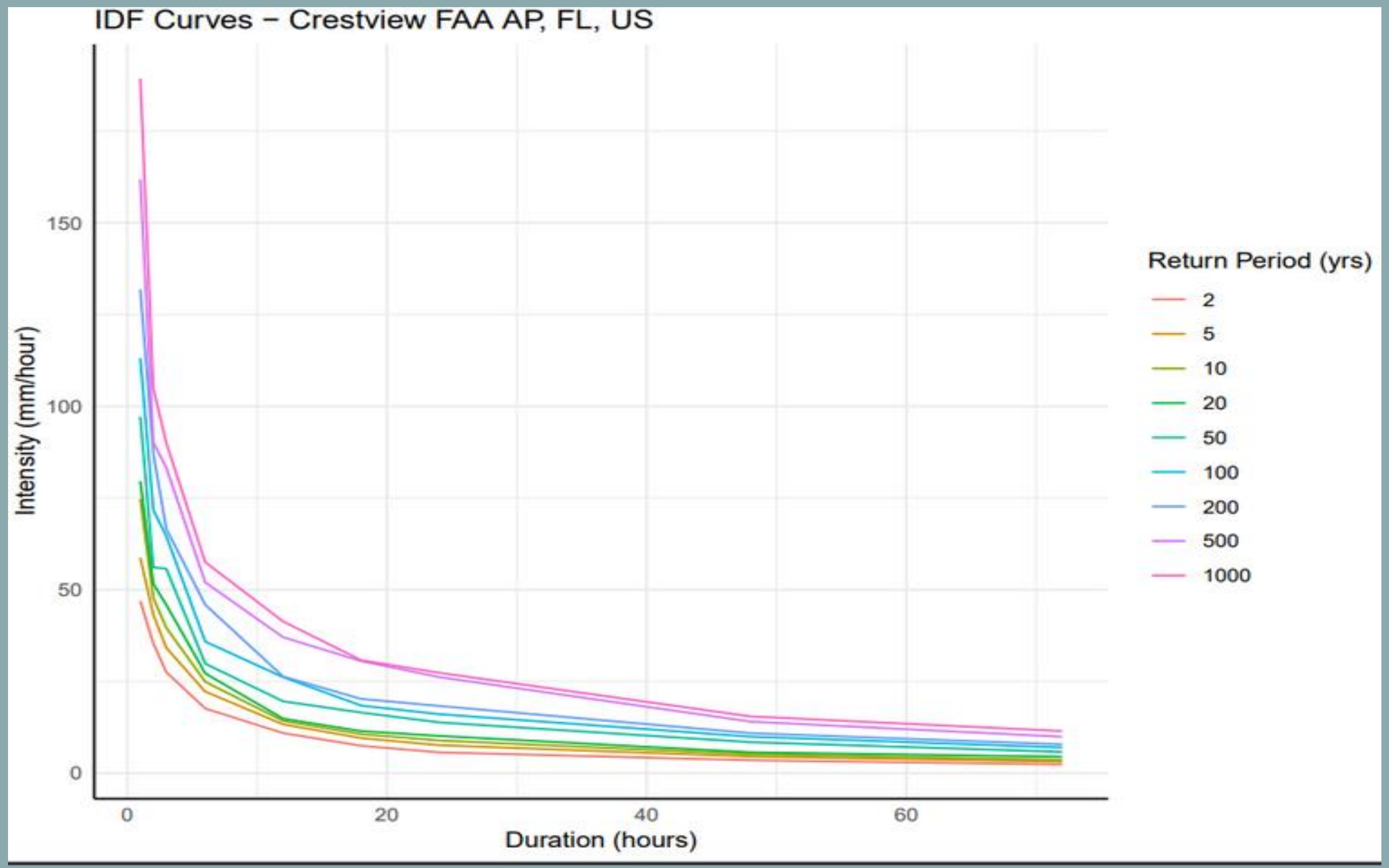
- Dataset for different durations developed from hourly dataset.

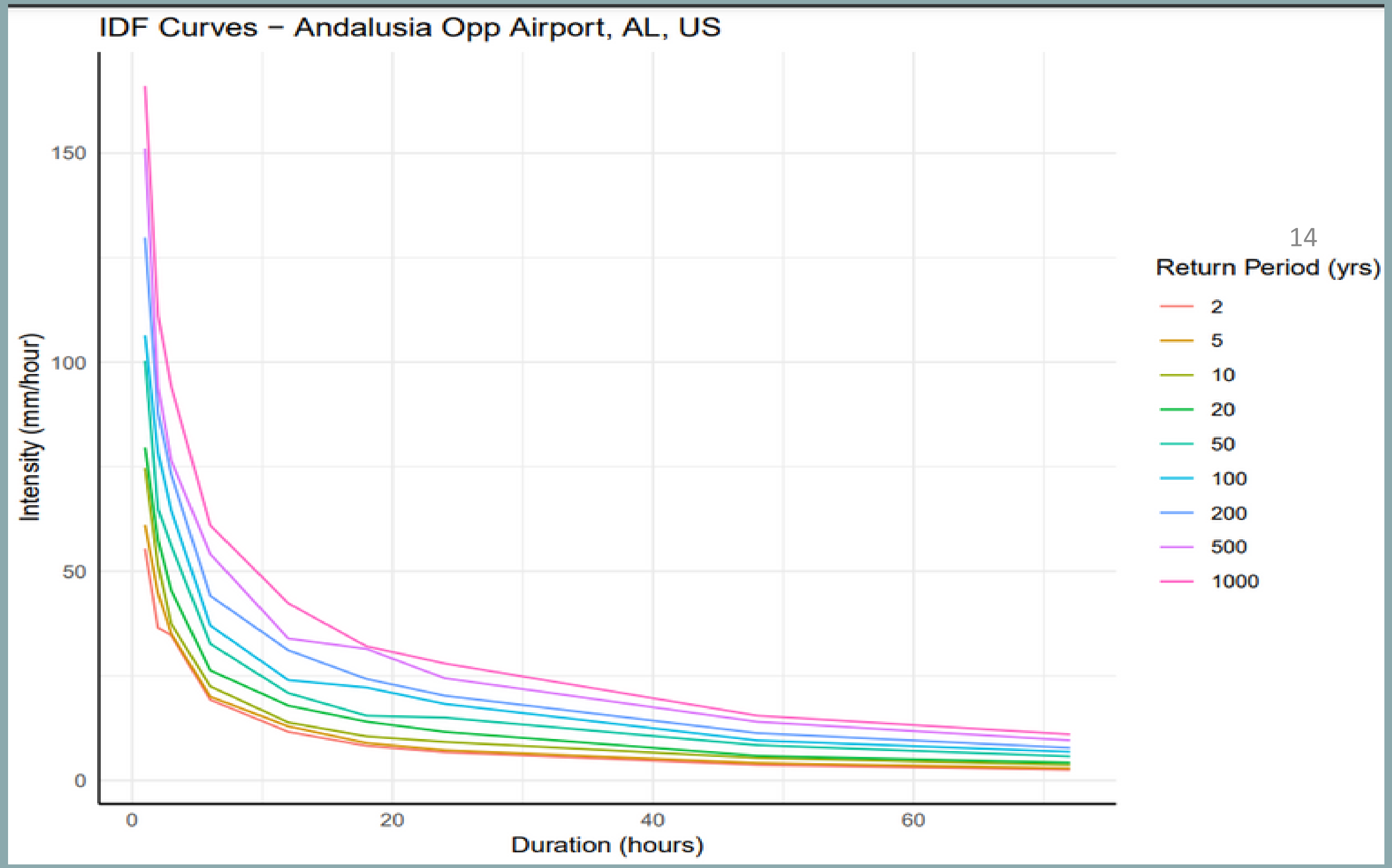


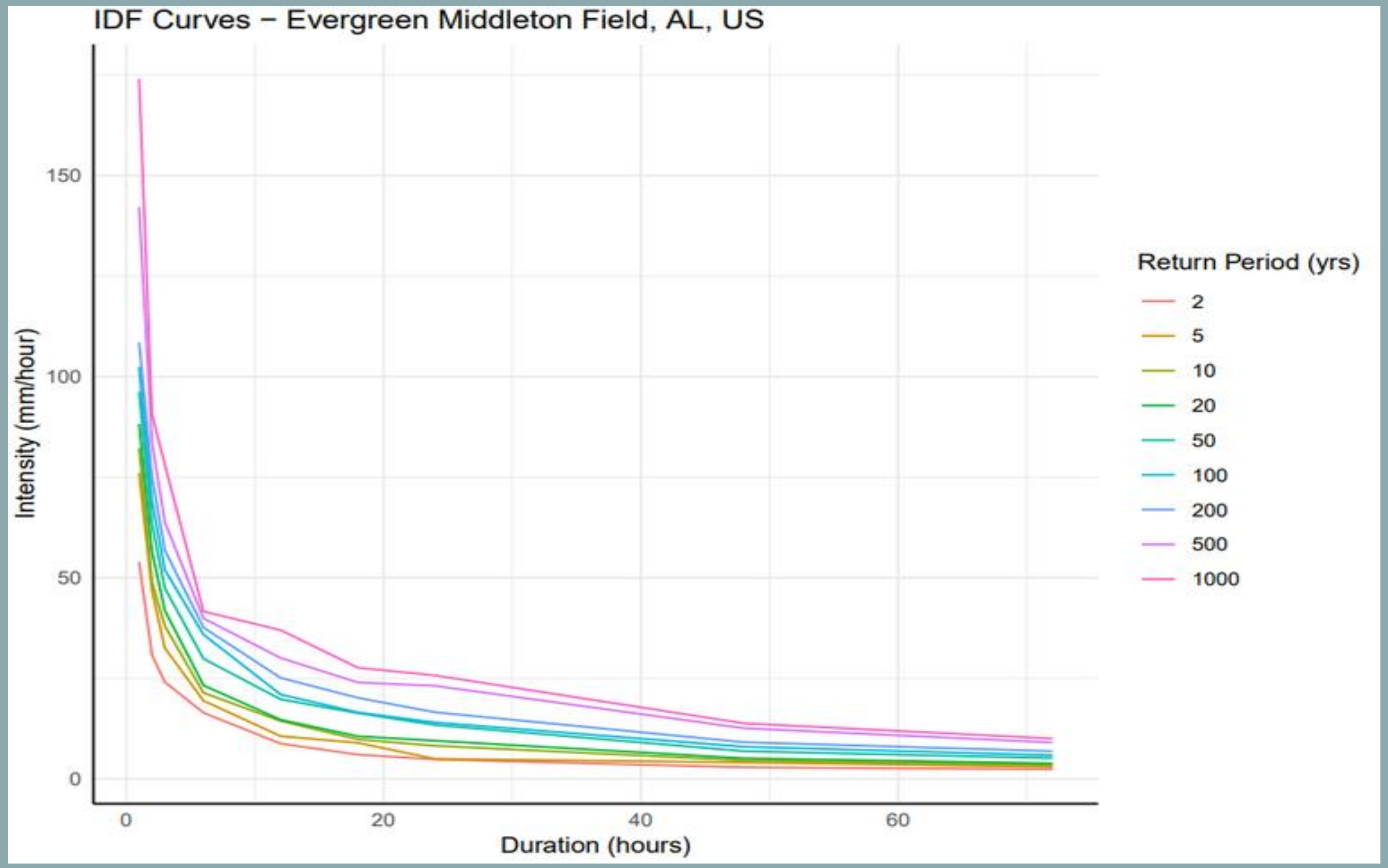
IDF Curves for Historical Precipitation (2007-2022)

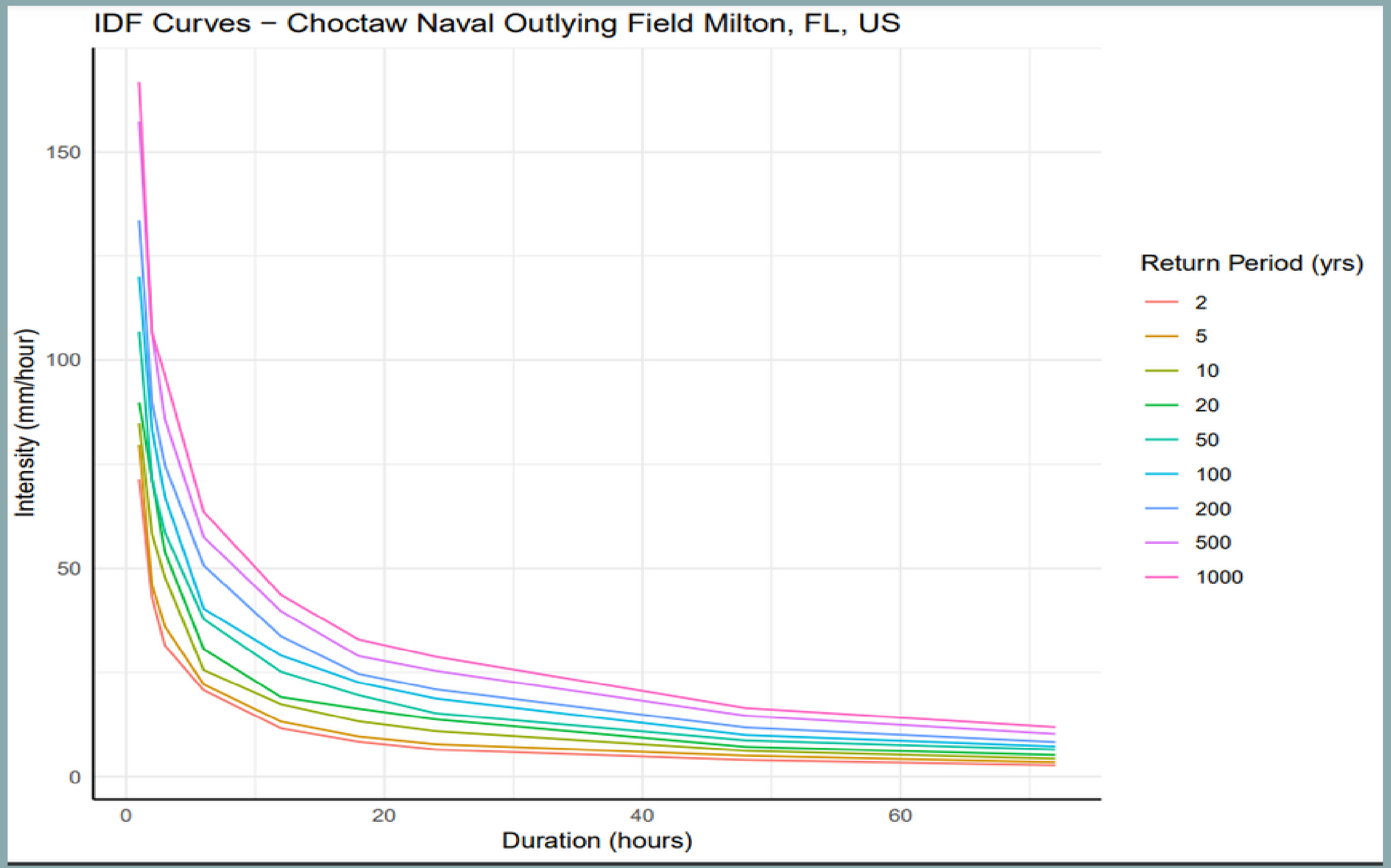



IDF Curves – Brewton 3 NNE, AL, US
Intensity (mm/hour)
Duration (hours)
Return Period (yrs)
2
5
10
20
50
100
200
500
1000

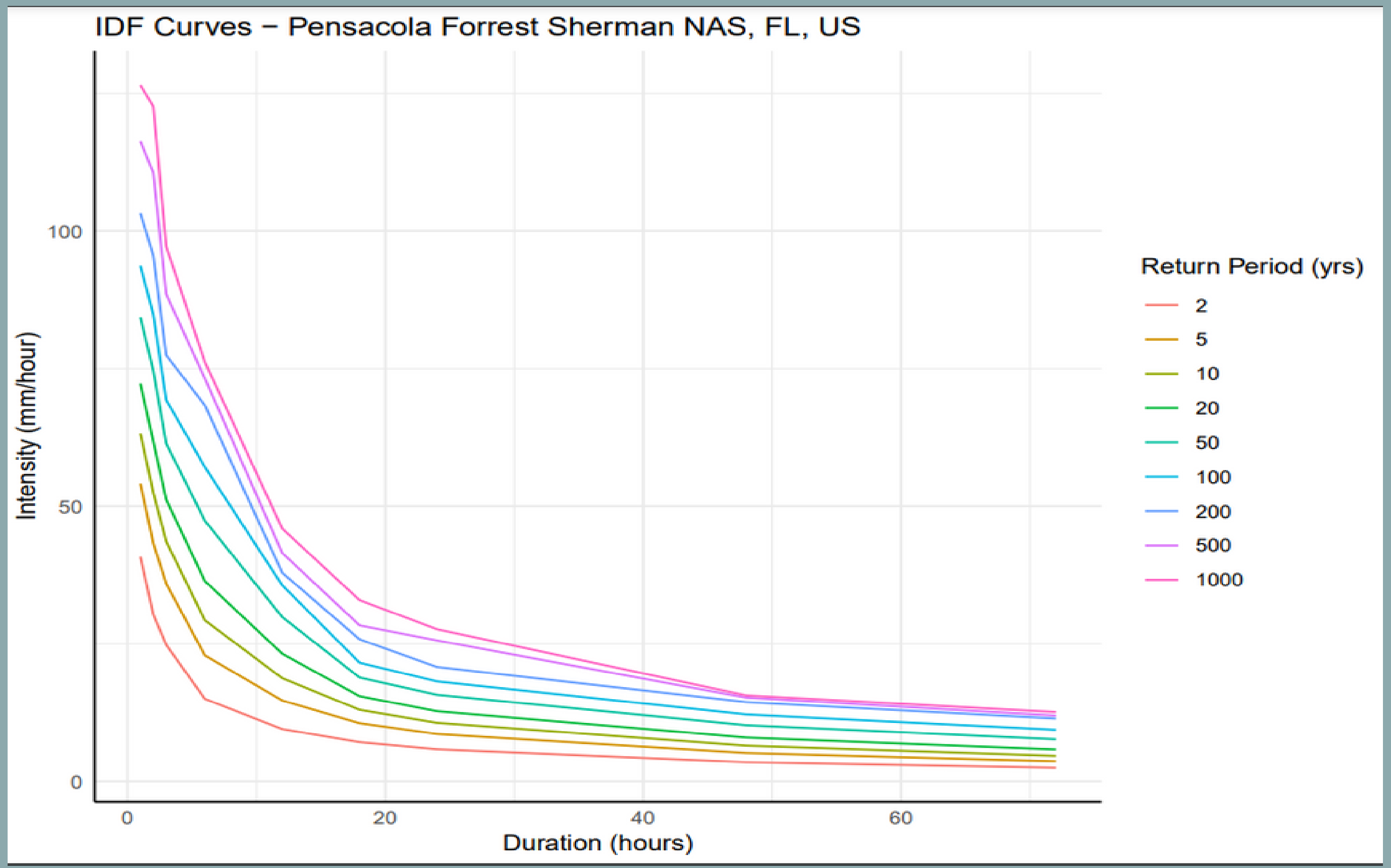

IDF Curves – Crestview FAA AP, FL, US
Intensity (mm/hour)
Duration (hours)
Return Period (yrs)
2
5
10
20
50
100
200
500
1000


IDF Curves – Andalusia Opp Airport, AL, US
Intensity (mm/hour)
Duration (hours)
14
Return Period (yrs)
2
5
10
20
50
100
200
500
1000

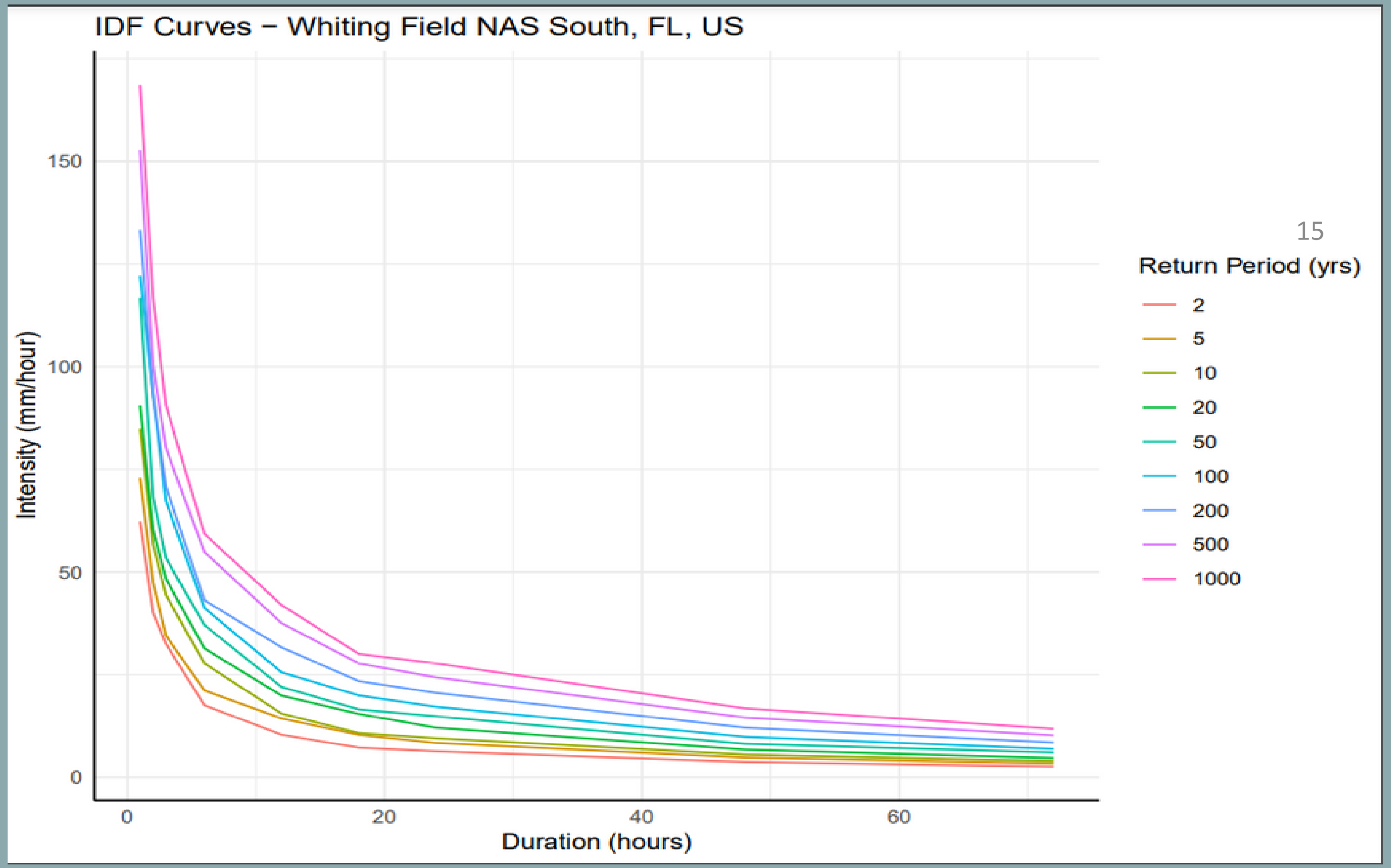

IDF Curves – Evergreen Middleton Field, AL, US
Intensity (mm/hour)
Duration (hours)
Return Period (yrs)
2
5
10
20
50
100
200
500
1000



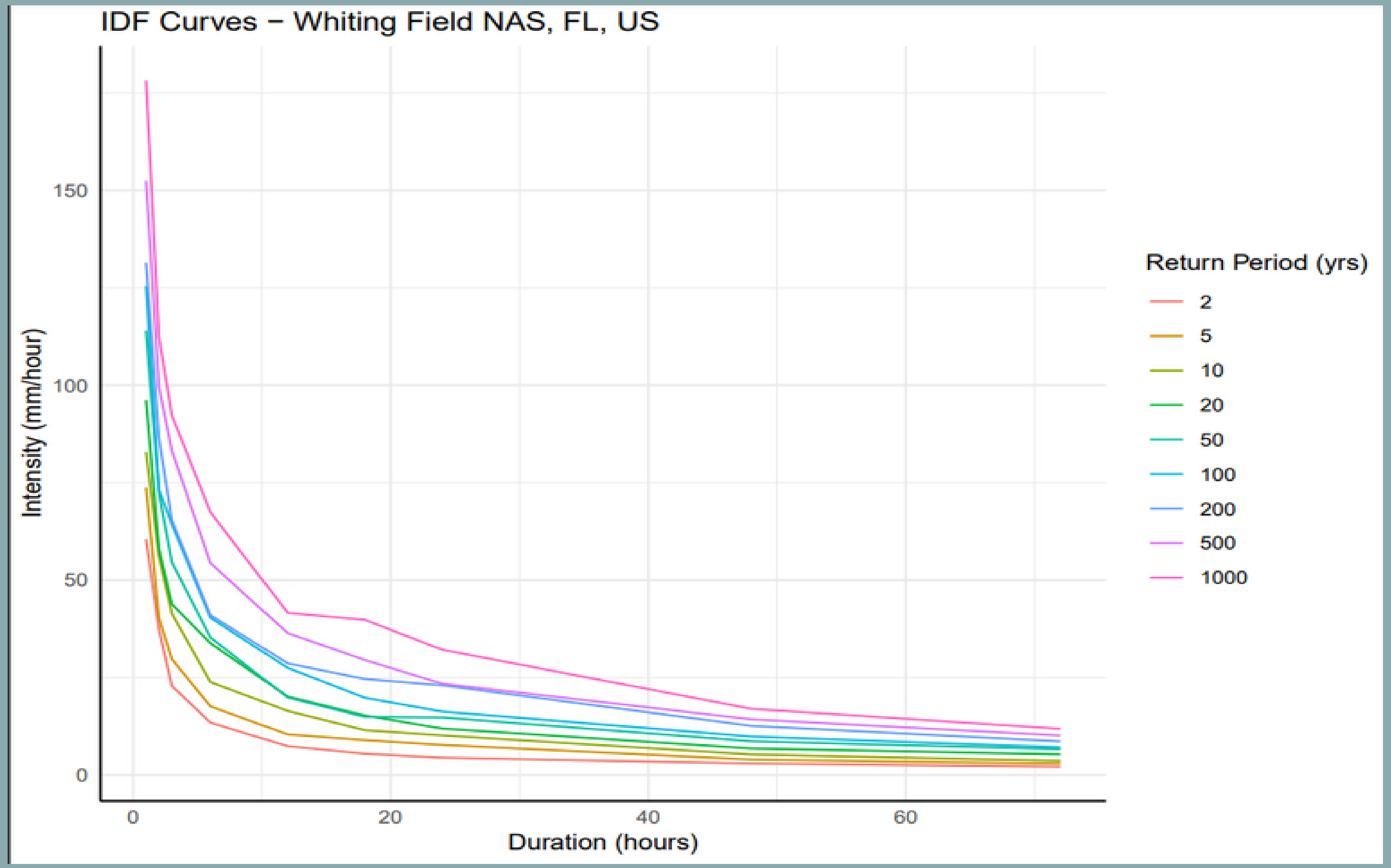
IDF Curves – Choctaw Naval Outlying Field Milton, FL, US
Intensity (mm/hour)
Duration (hours)
Return Period (yrs)
2
5
10
20
50
100
200
500
1000



IDF Curves – Pensacola Forrest Sherman NAS, FL, US
Intensity (mm/hour)
Duration (hours)
Return Period (yrs)
2
5
10
20
50
100
200
500
1000

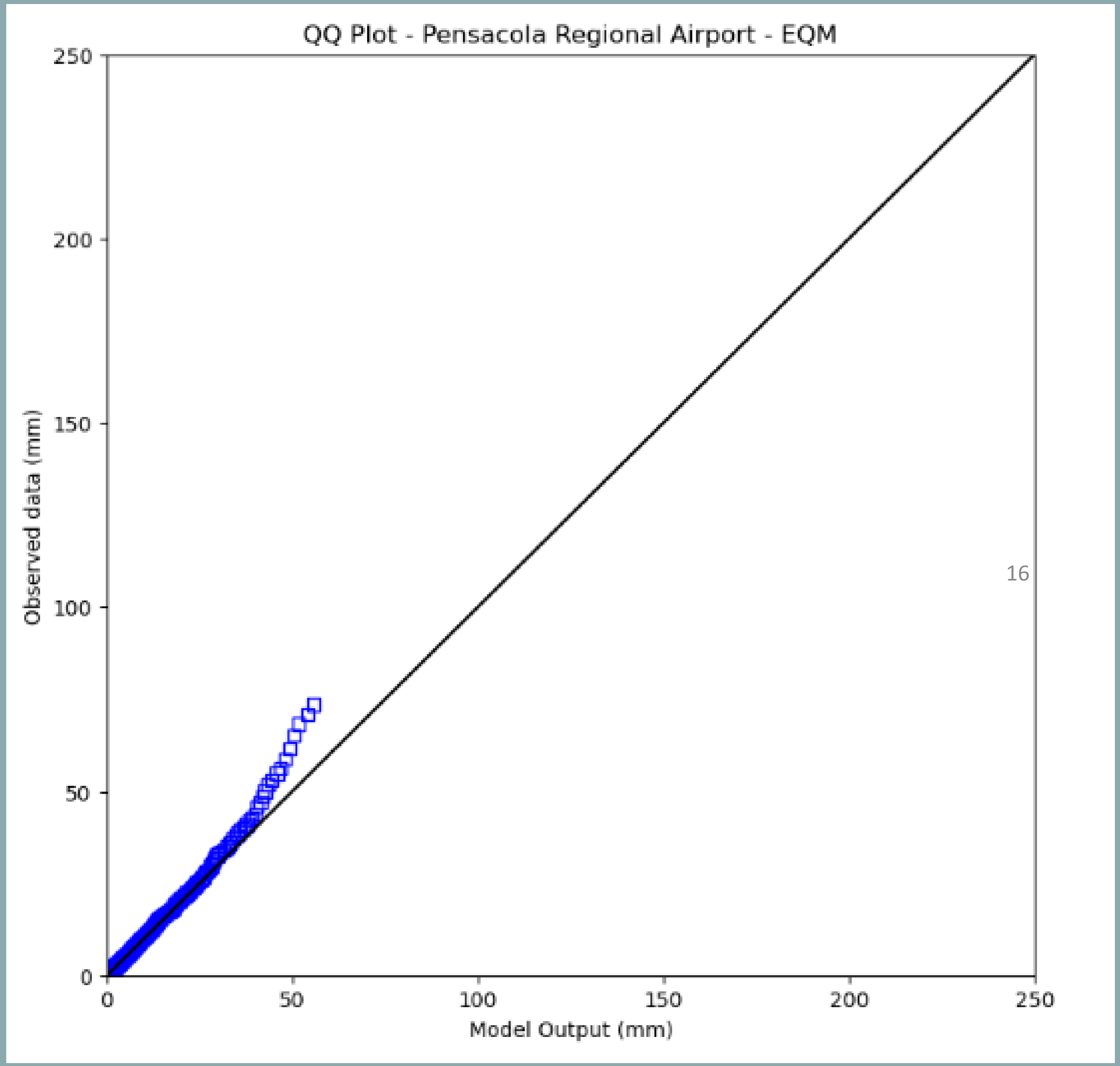


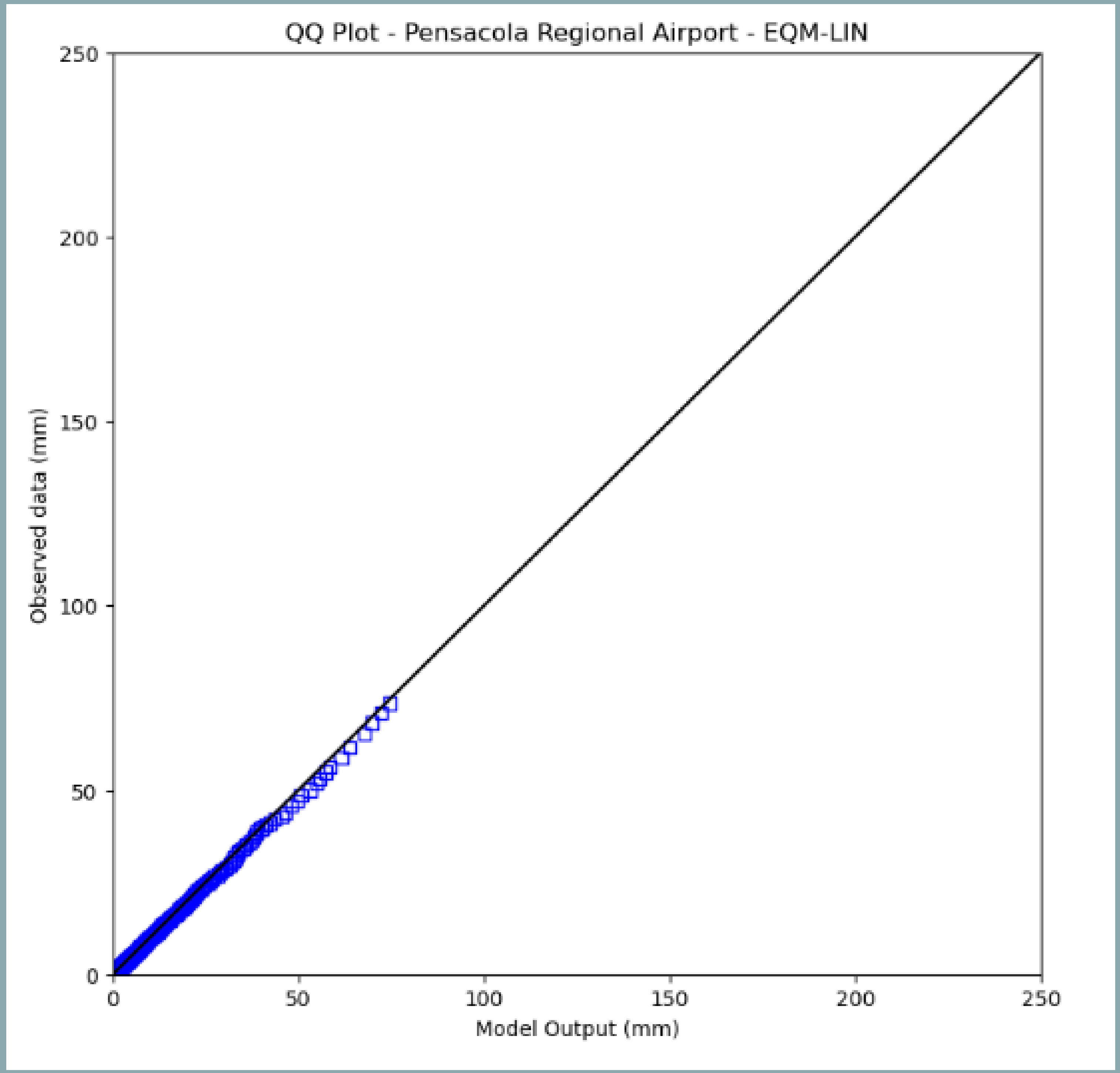
IDF Curves – Whiting Field NAS South, FL, US
Intensity (mm/hour)
Duration (hours)
15
Return Period (yrs)
2
5
10
20
50
100
200
500
1000



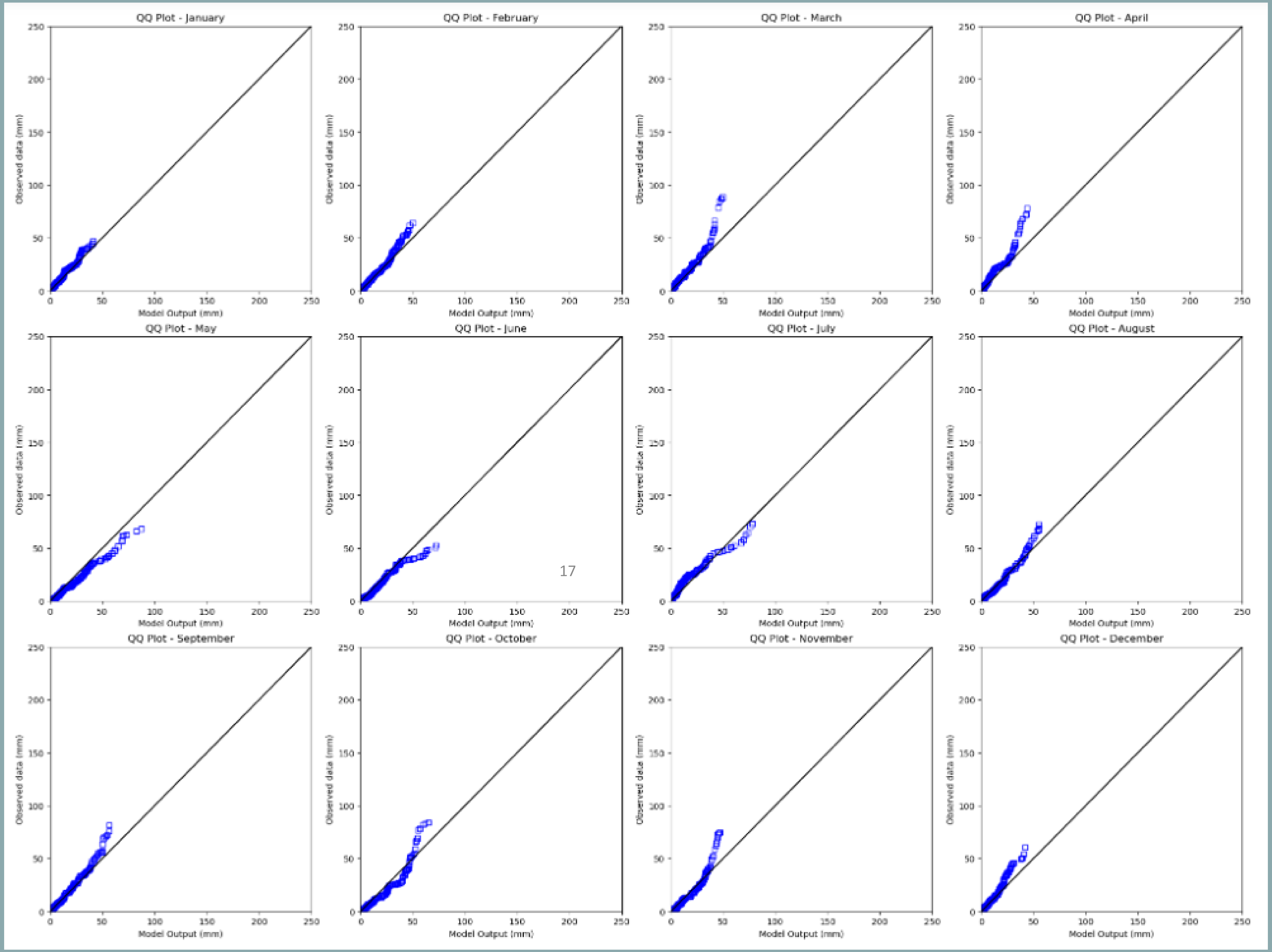
IDF Curves – Whiting Field NAS, FL, US
Intensity (mm/hour)
Duration (hours)
Return Period (yrs)
2
5
10
20
50
100
200
500
1000

Bias Correction Performance of EQM and EQM-LIN on Annual Scale

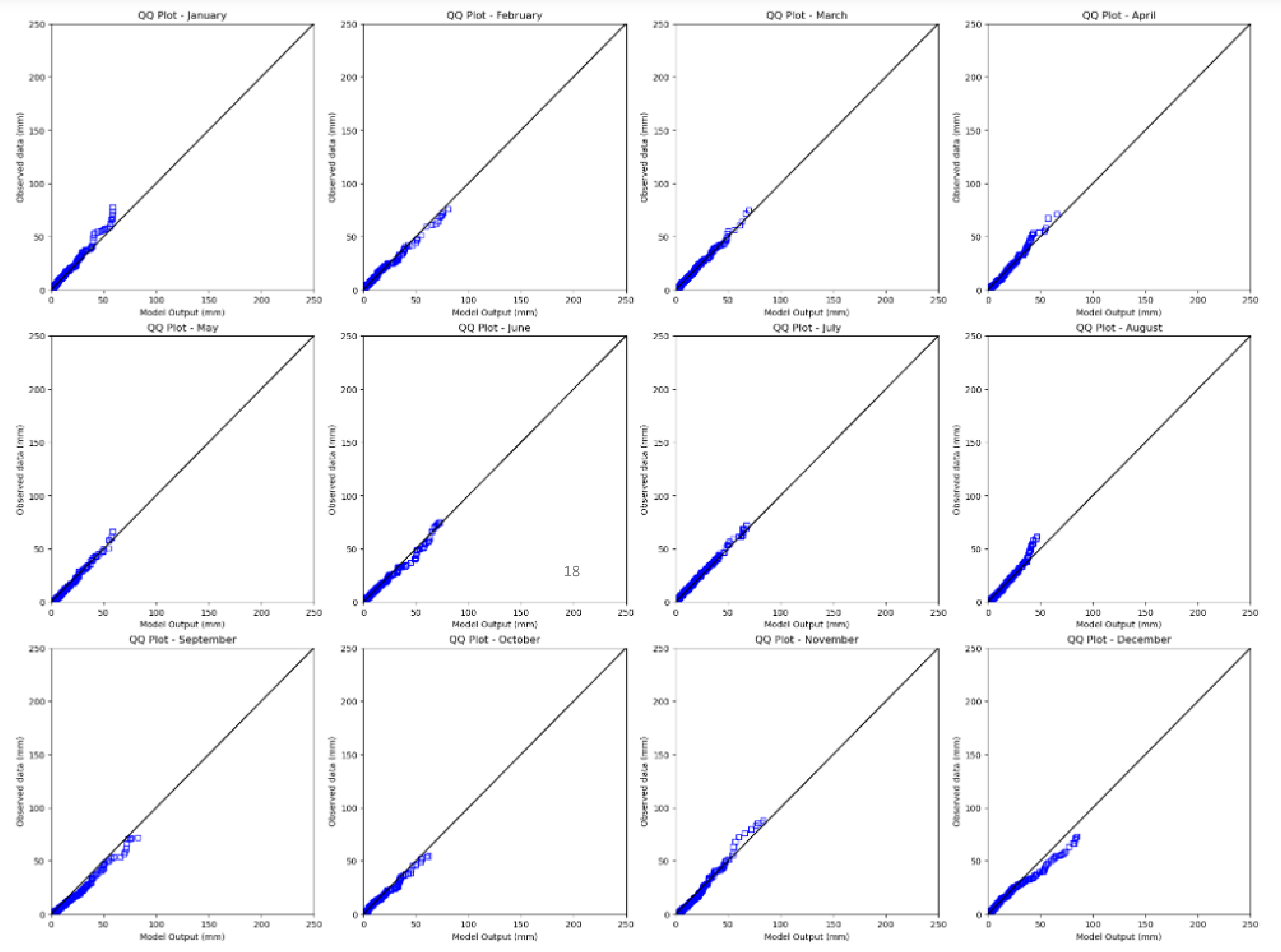




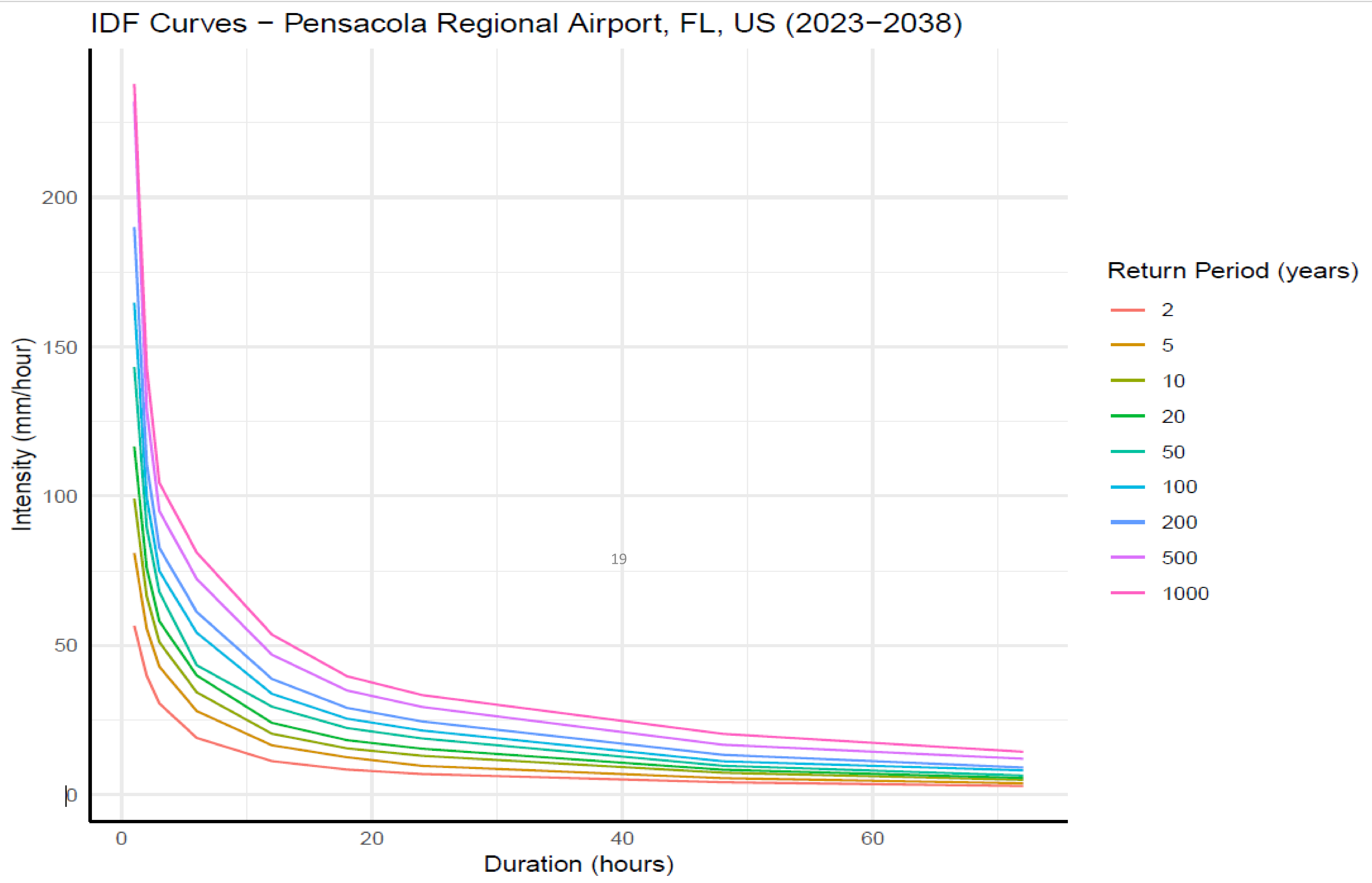
Bias Correction Performance by Month: EQM



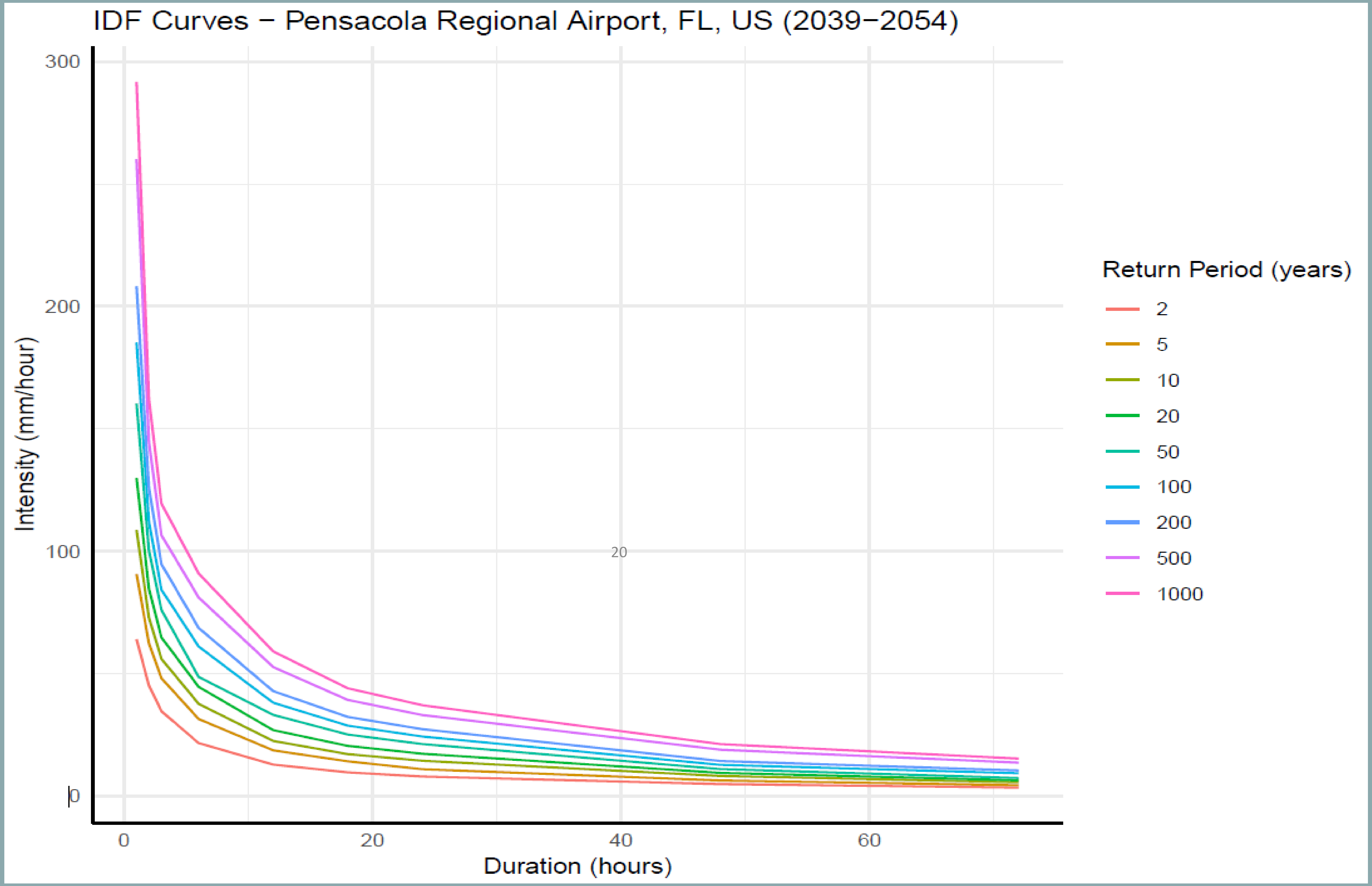
Bias Correction Performance by Month: EQM-LIN



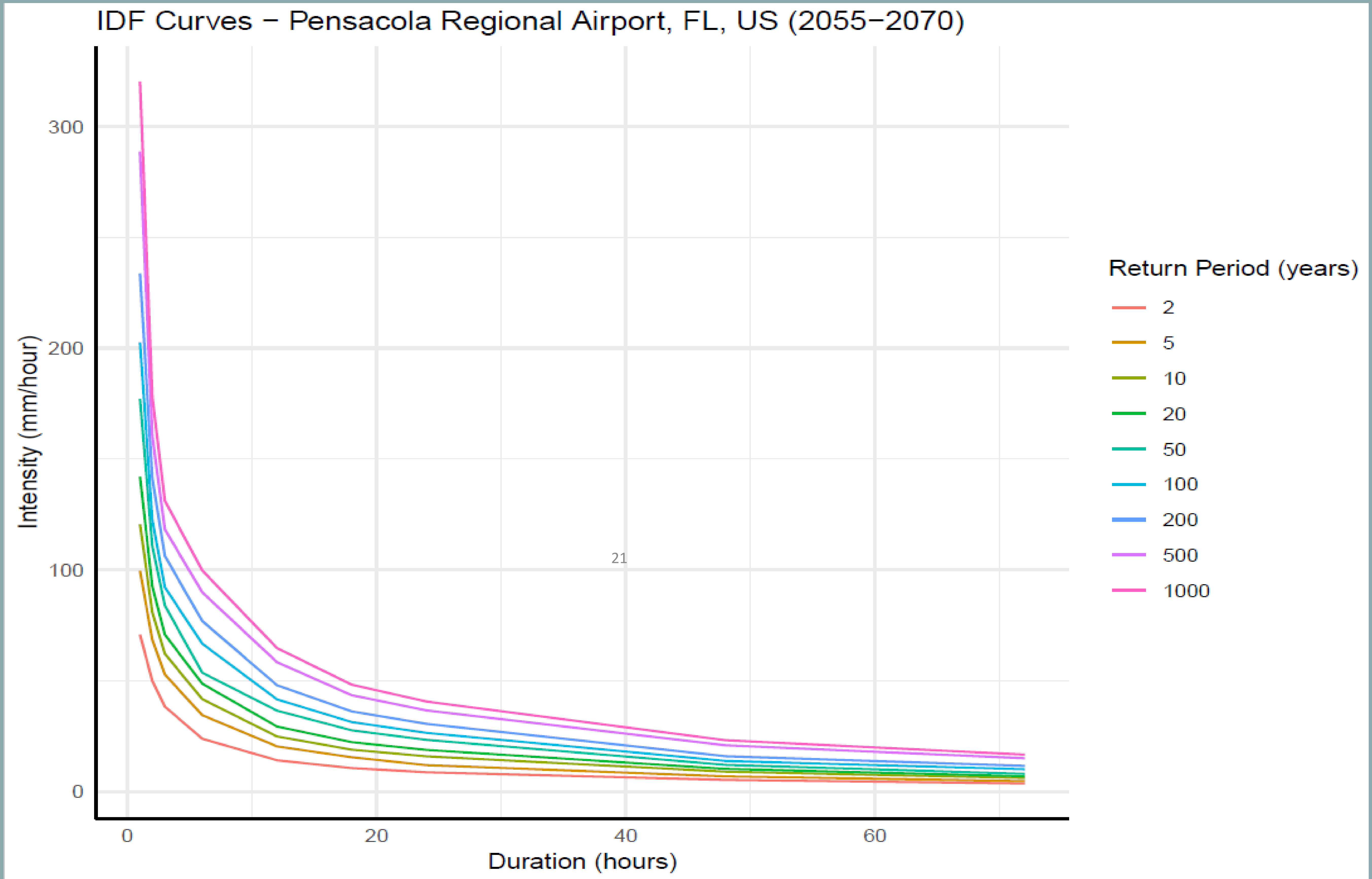
IDF Curves for Near Future (2023 – 2038)



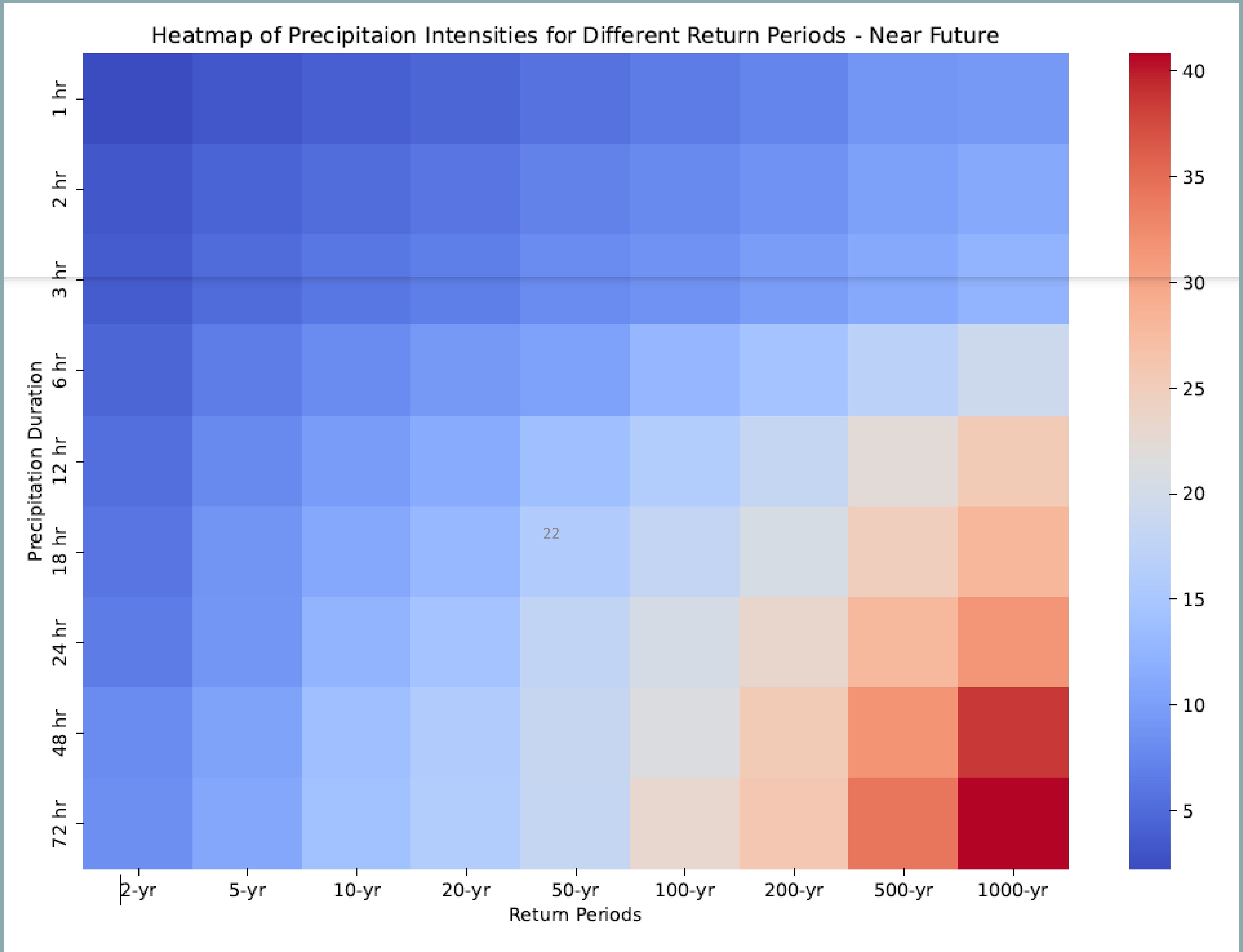
IDF Curves for Mid Future (2039-2054)



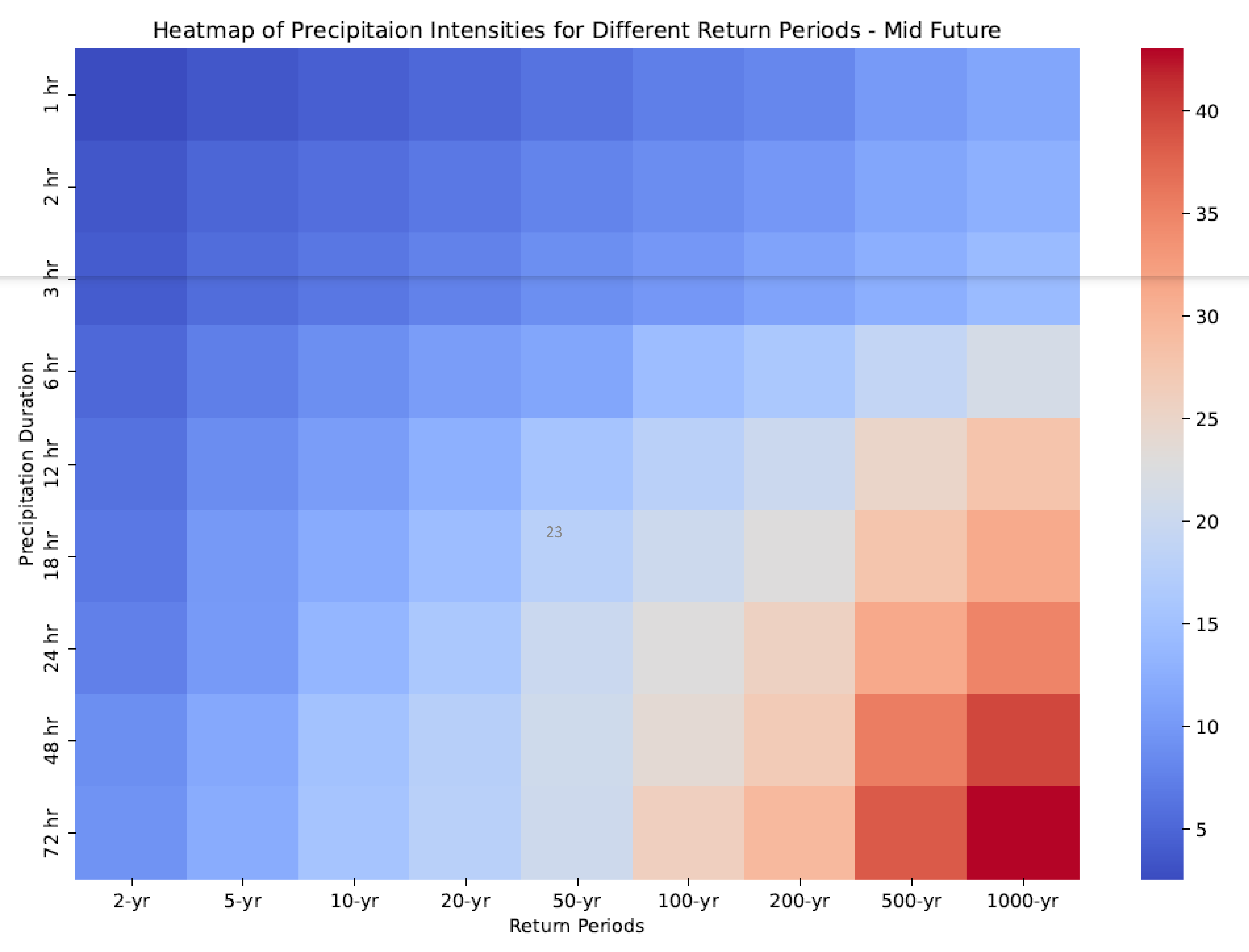
IDF Curves for Distant Future (2055-2070)



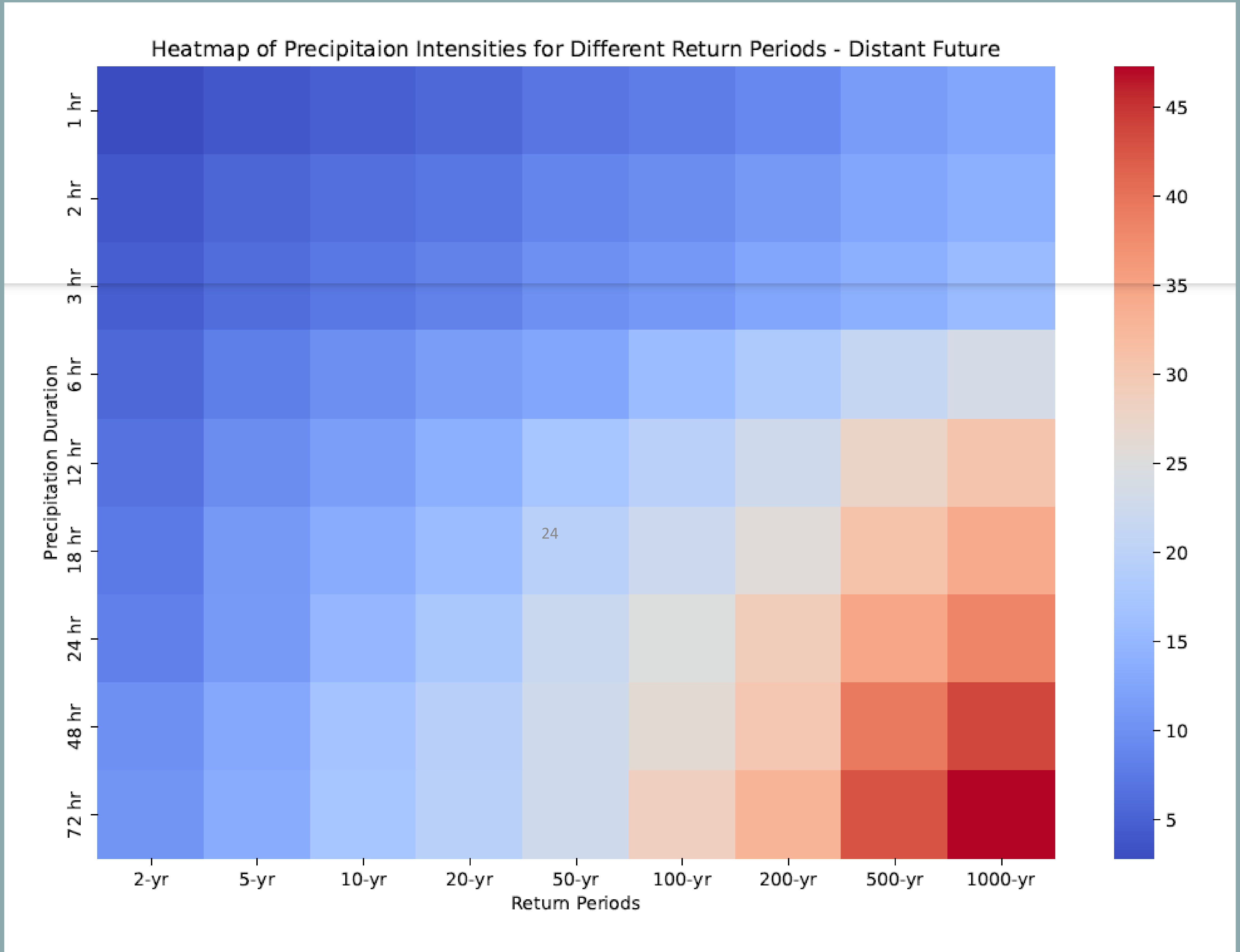
Heatmap of Precipitation Intensities – Near Future (2023-2038)



Heatmap of Precipitation Intensities – Mid Future (2039–2054)



Heatmap of Precipitation Intensities – Distant Future (2055-2070)



Key Findings

- EQM-LIN outperformed EQM for bias-correcting the outliers.
- Increasing intensities in the future.
- Rate of change in far future is the highest followed by mid and near future.

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- Increasing rate of intensities in higher duration precipitations.
- Rate of change has is increasing with the higher return periods.

Future Works

- Application of other climate scenarios, temporal disaggregation methods and probability distributions (i.e. General Pareto).

- Peak-Over-Threshold (POT) method and Generalized Maximum Likelihood Estimation (GMLE) for distribution fitting.

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- Application of different GCM and RCMs and comparison between their performances.

Acknowledgements

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THANK YOU

QUESTIONS?

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