

Precipitation Intensity-Duration-Frequency Analysis in the Face of Climate Change and Uncertainty

Supporting Casco Bay Region Climate Change Adaptation RRAP

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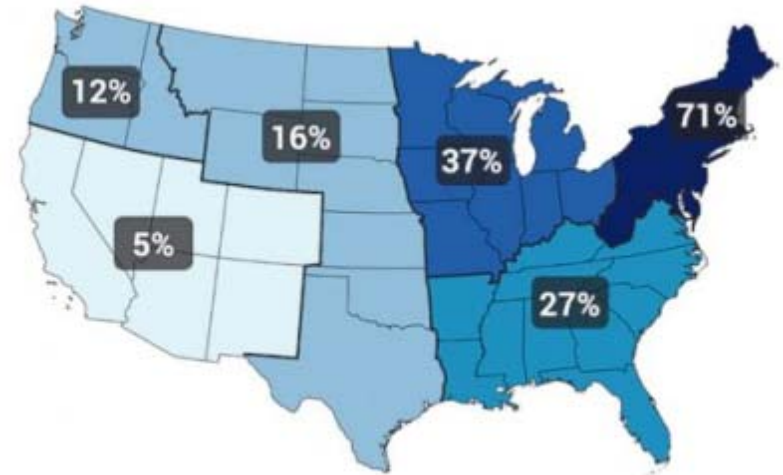
Argonne National Laboratory

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Need to Update IDF Curve Development

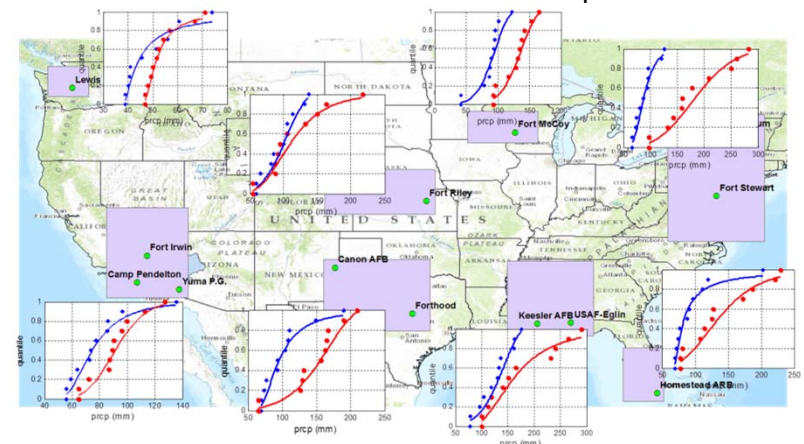
- Challenges in quantifying extreme events
 - The most extreme precipitation events (or heaviest 1% of all daily events) have increased in every region of the contiguous states since the 1950s
 - Climate change projections suggest increased likelihood of extreme precipitation events
 - Uncertainty in quantifying extreme events
- Regional resilience assessment requires improved understanding of:
 - Non-uniform spatial and temporal distribution of potential climate-induced changes in intensity and variability of extreme events
 - Adaptation responses to these changes
 - Uncertainty, source of uncertainty, and associated risks
- Cities/regions need this information to inform design of precipitation-affected infrastructure

Observed change in heavy precipitation from 1958 to 2012



Source: National Climate Assessment Report, 2014

Historical (blue) and Forecasted (red) Cumulative Distribution Function for 3-h Precipitation

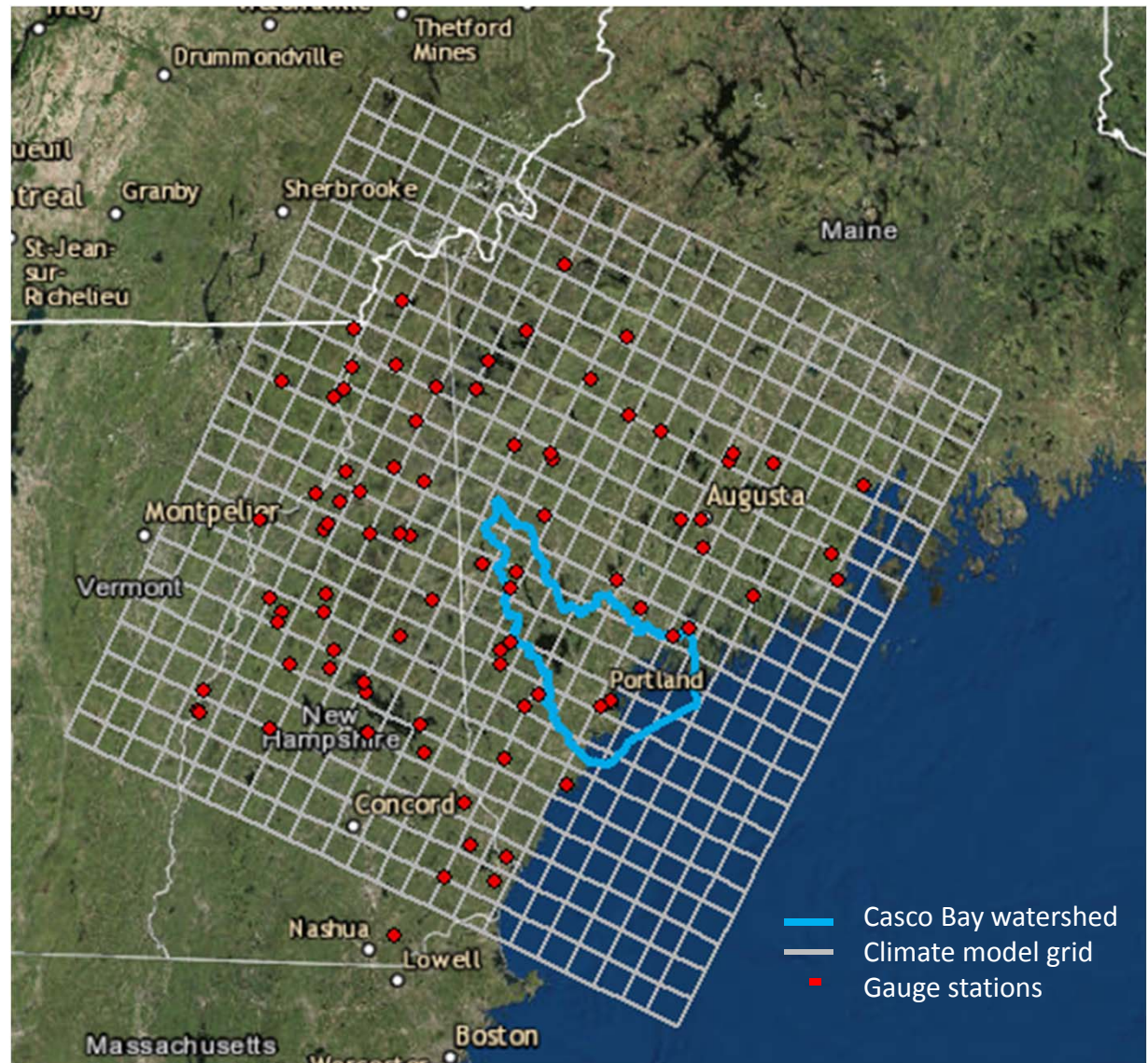


Source: Argonne National Laboratory

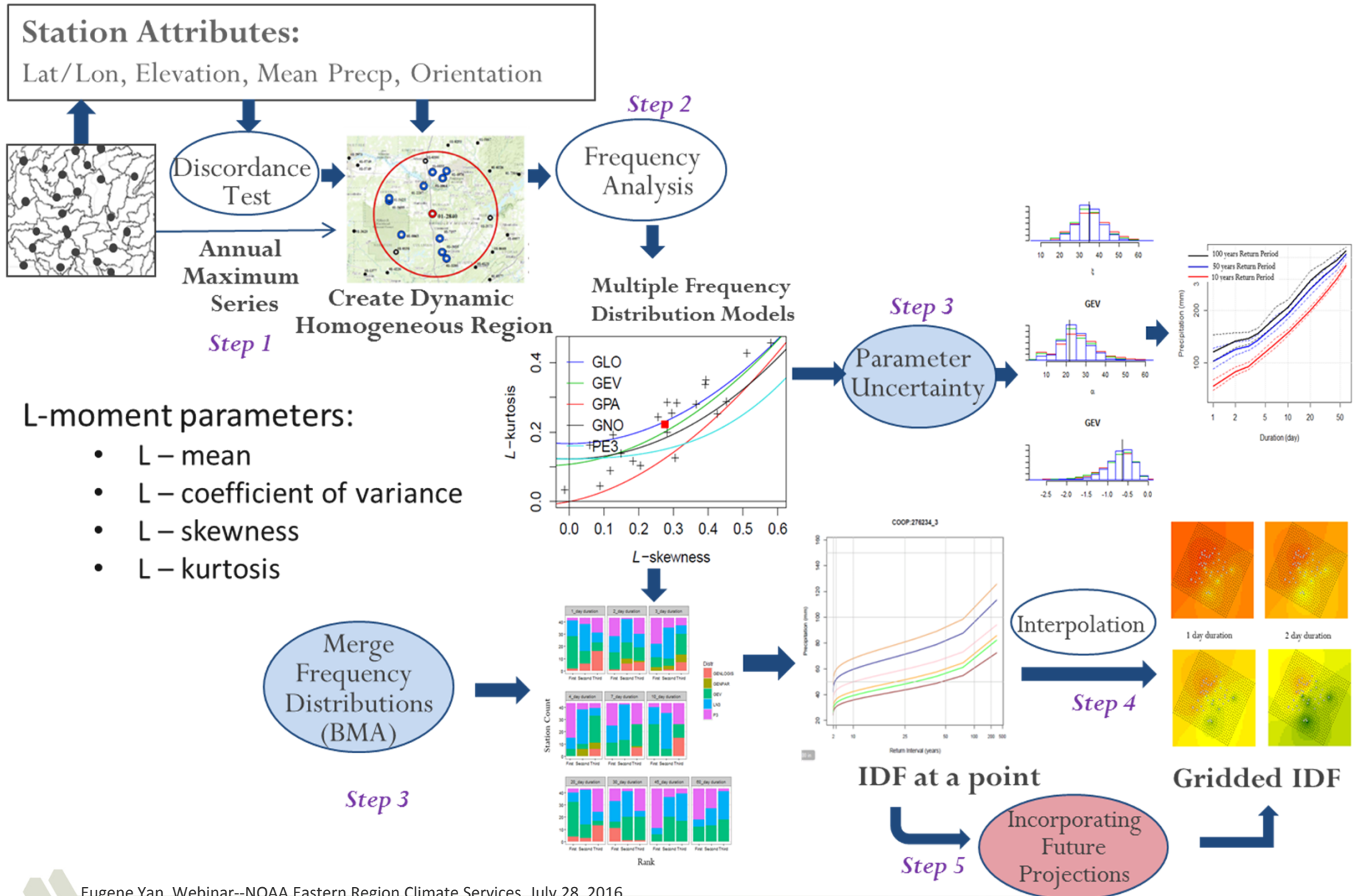


Casco Bay Region

- Casco Bay watershed
 - City of Portland located downstream of the watershed
 - Recent flooding in 2007 impacted by both stream flow and costal storm
- Data sources:
 - Precipitation records from 85 daily rain gages and 15 hourly gages from NOAA
 - Precipitation projections (shown as grid) extracted from regional climate modeling results by Argonne using WRF (1965-2004; 2035-2065)

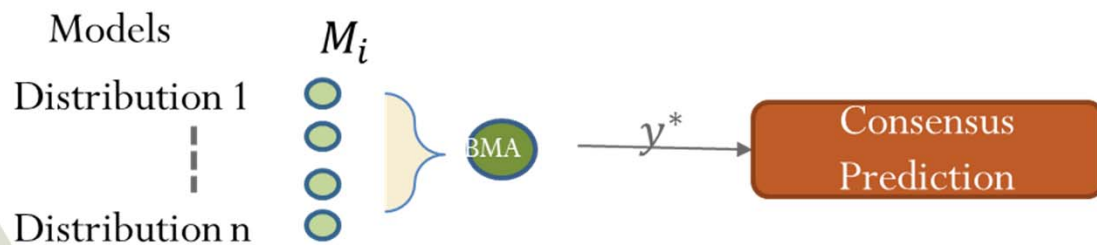
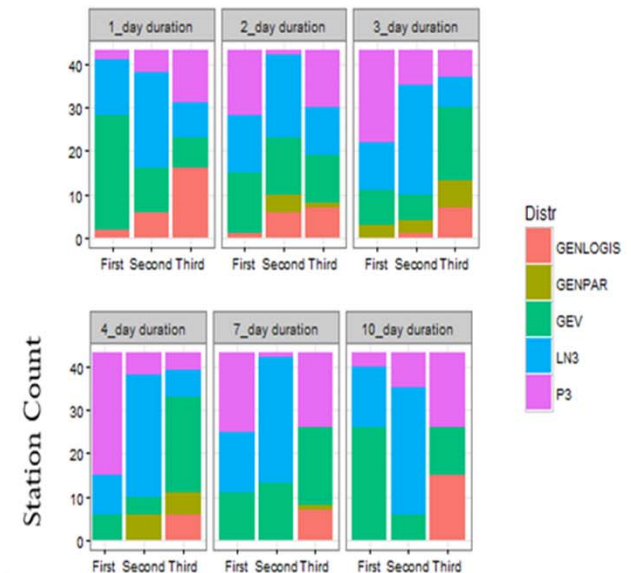
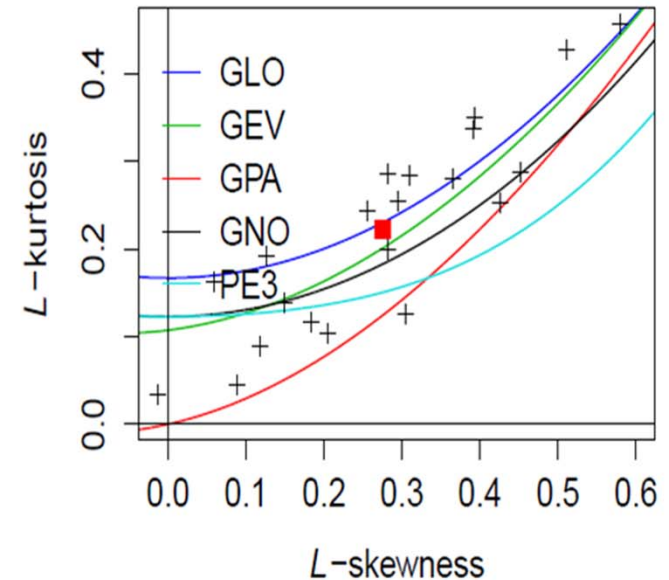


Processes for IDF Development



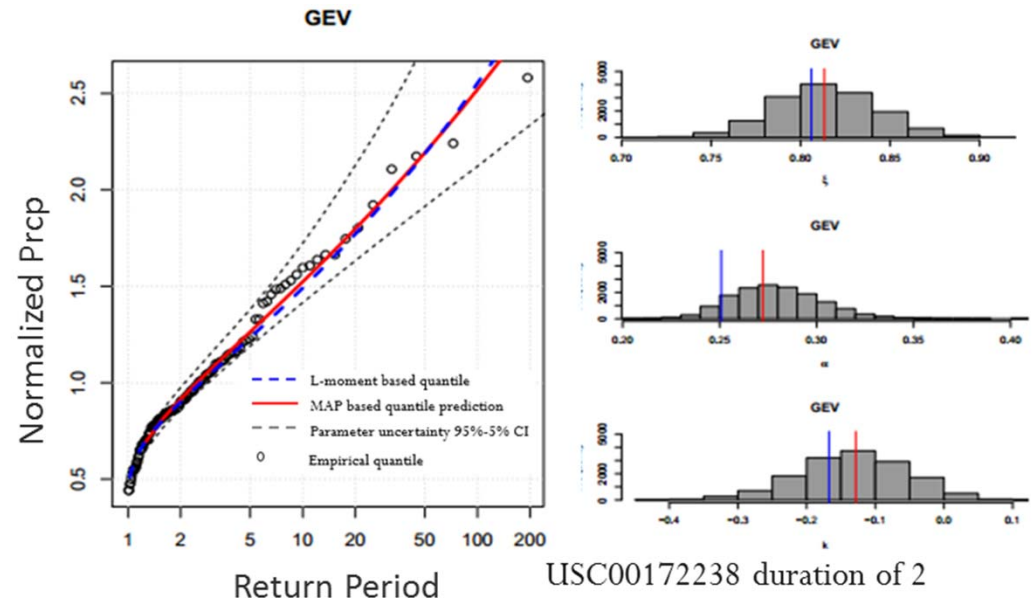
Model Selection and Uncertainty

- Distribution model
 - Five distributions considered
 - Ranked by goodness-of-fit measure using L-skewness and L-kurtosis
- Model uncertainty
 - Wide range of preferred distribution models for each of 10 durations in Casco Bay region
 - Best model could not be confidently identified
- Bayesian model averaging (BMA) method
 - Combine a number of plausible models together through weighting
 - Derive the weights from models' posterior performances
 - provides deterministic forecast with the associated forecast distribution

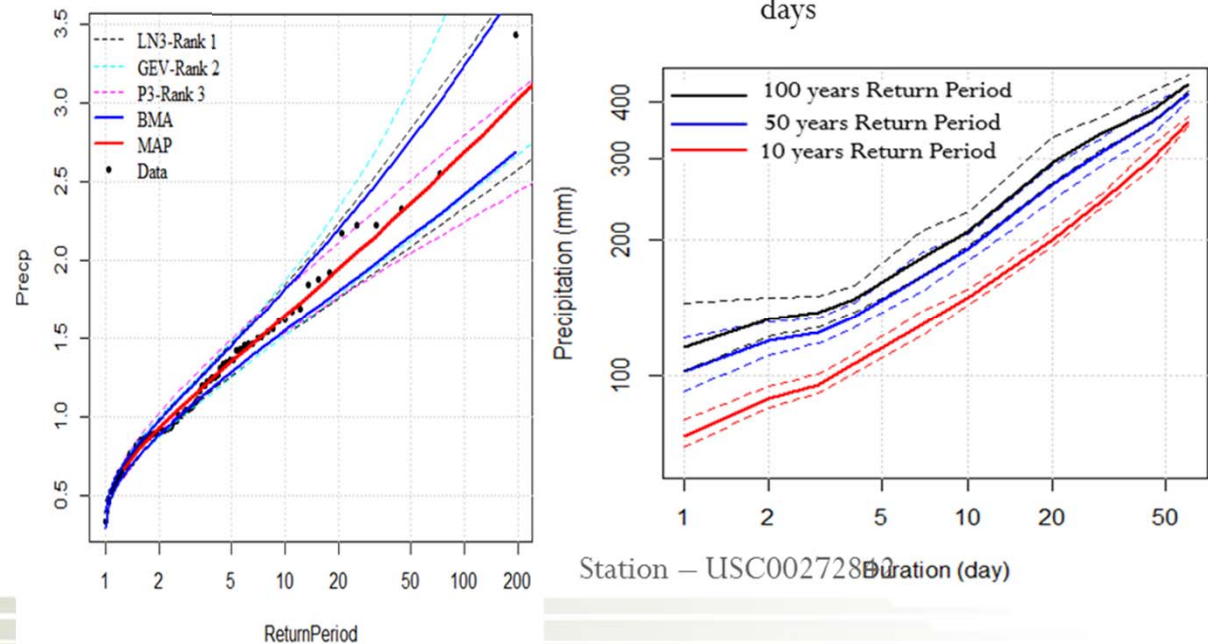


Identification of Parameter Uncertainties

- Bayesian approach
 - Sample the entire parameter posterior distribution
 - Determine distribution parameters (location, scale, and shape) using MAP vs. L-moment estimates
 - Provide uncertainty band (95%-5%) based on parameter posterior distribution

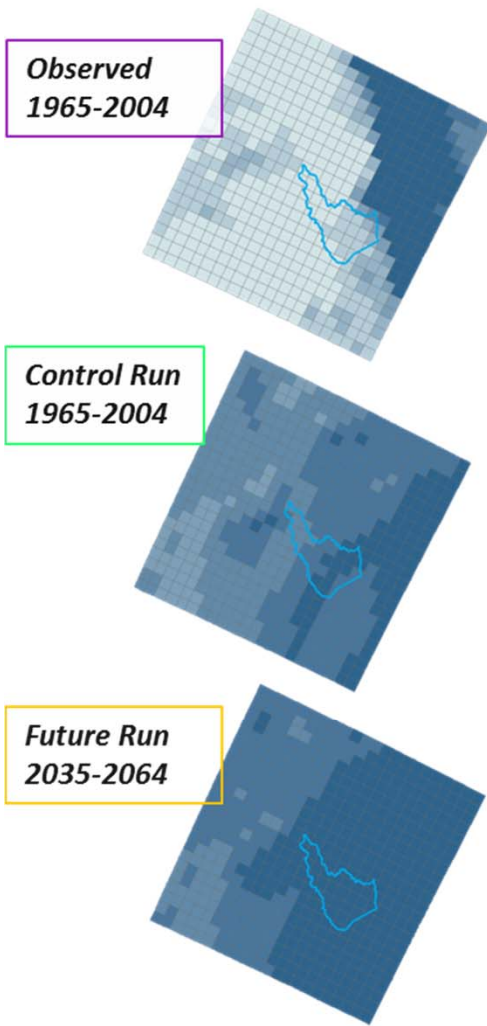


- Predictive uncertainty
 - Incorporate both parameter and model uncertainties
 - Reduced predictive uncertainty under BMA
 - Uncertainty implication – risk probability

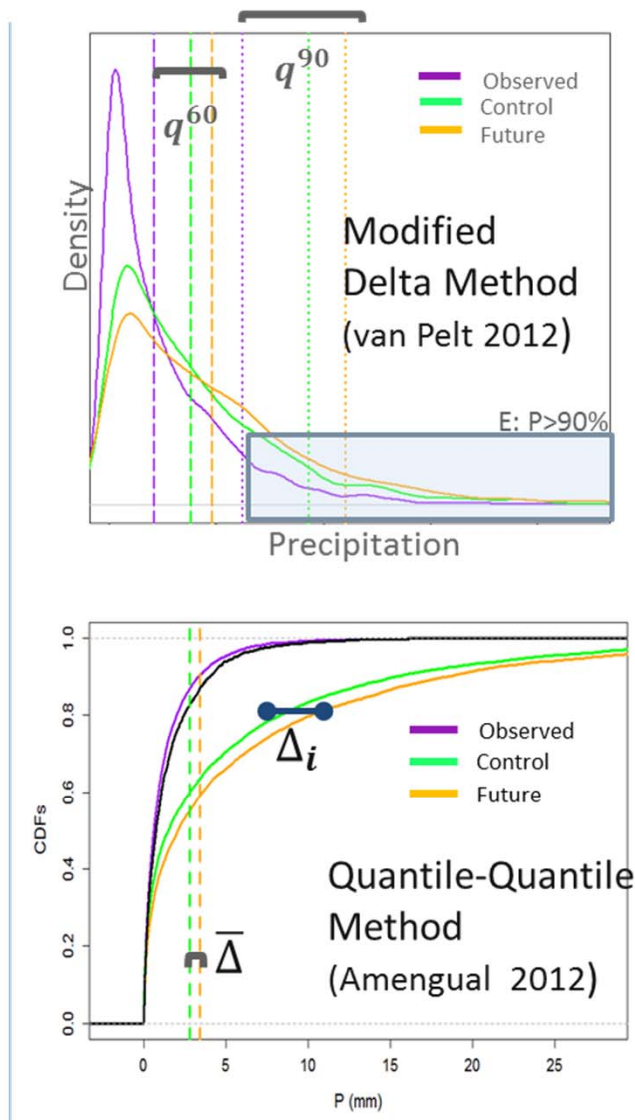


Incorporating Future Projections in IDF

1. DATA



2. TRANSFORMATION FACTORS



3. TRANSFORMED DATA

- (A) Apply changes in the means:

$$\text{for } P_{obs} < q_{obs}^{90} : P_{trans} = \alpha P_{obs}^{\beta}$$
- (B) Apply changes in the extremes:

$$\text{for } P_{obs} > q_{obs}^{90} : P_{trans} = \frac{E_{fut}}{E_{control}} * (P_{obs} - q_{obs}^{90}) + \alpha (q_{obs}^{90})^{\beta}$$
- (C) Transformed observation data including future signal

Apply quantile factors:

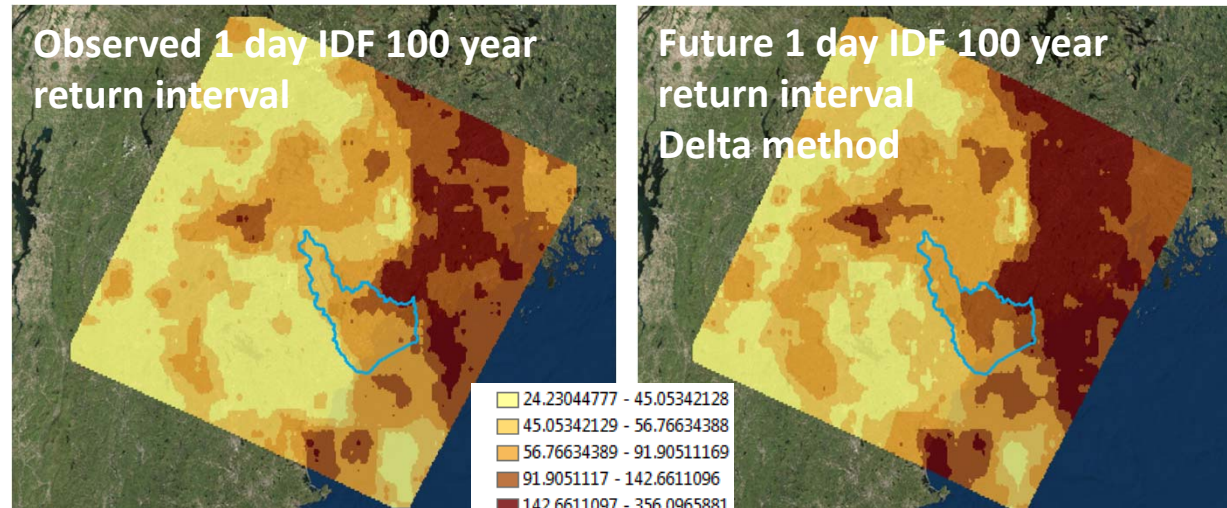
$$P_{trans} = P_{obs} + g\bar{\Delta} + f(\Delta_i - \bar{\Delta})$$

 g – mean adjustment
 f – scale adjustment

 Remove difference between controlled and observed quantile

Results of IDF Analysis Incorporating Future Projections

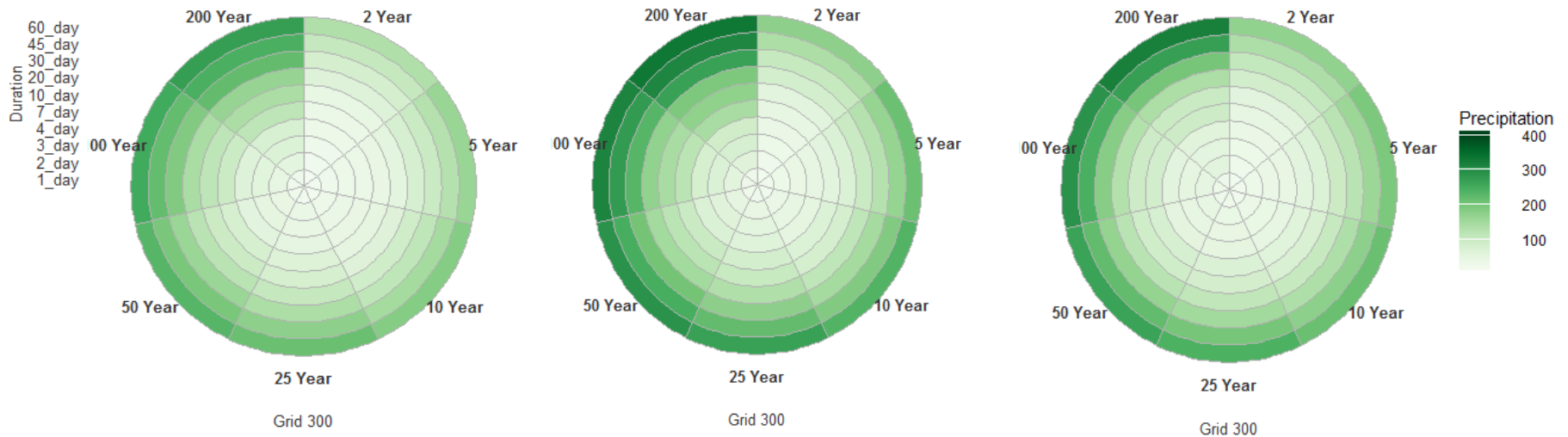
- Increased intensity for all durations and return period events
- More increase in high return-period events
- Spatial variations in change of IDF



Observed
(Multiple Temporal Scale)

DELTA
(Multiple Temporal Scale)

QQ method
(Multiple Temporal Scale)



Future Work

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- Identify and incorporate uncertainties from regional climate models
- Develop Runoff IDF for Casco Bay region
- Explore feasibility to include radar data in development of sub-daily IDF and improve the quality of sub-daily IDF due to vary limited number of hourly rain gage stations.

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