NARCCAP Model Comparison of Extreme Rainfall Intensity in the Continental US

Peng Gao and Greg Carbone

Carolinas Integrated Sciences and Assessments (CISA)

Department of Geography, University of South Carolina

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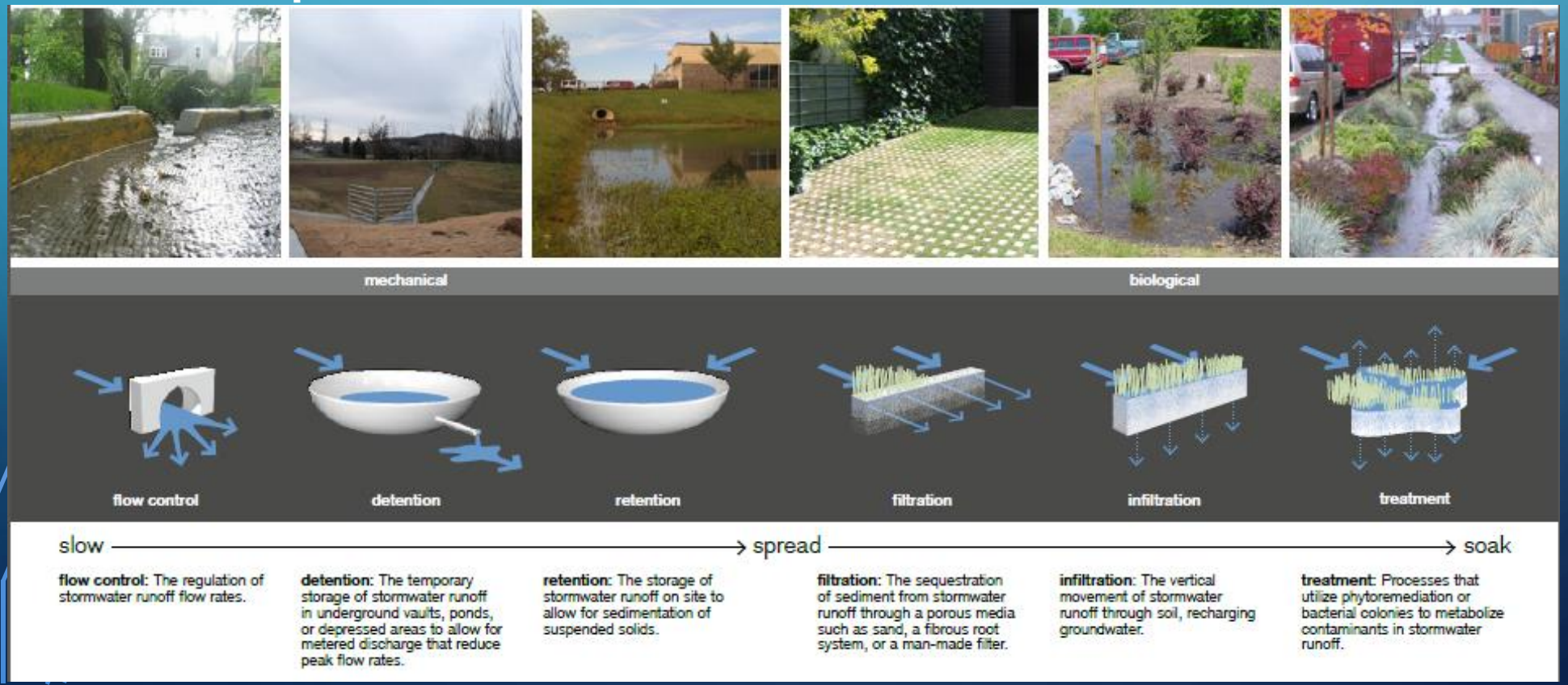
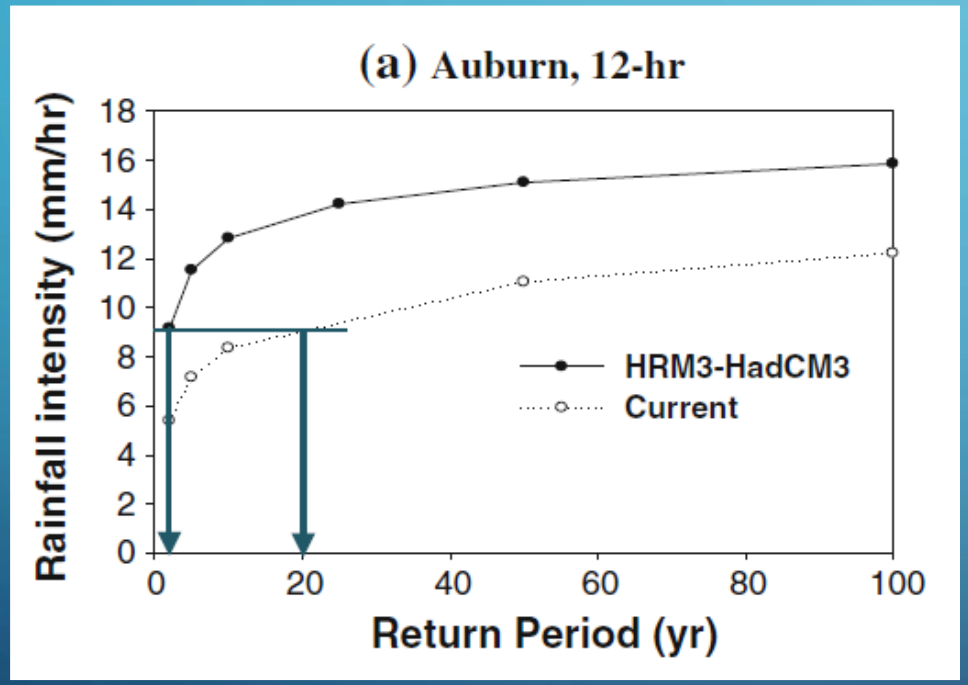
Introduction

- **Extreme rainfall events: the design of infrastructure and facilities**
  - **Stormwater management**
  - **Erosion and sediment control**
  - **Flood protection** (McCuen 1998; Prodanovic and Simonovic 2007; Mirhosseini et al. 2013)



Introduction

- The Generalized Extreme Value theory (GEV): Intensity-Duration-Frequency (IDF) Curves



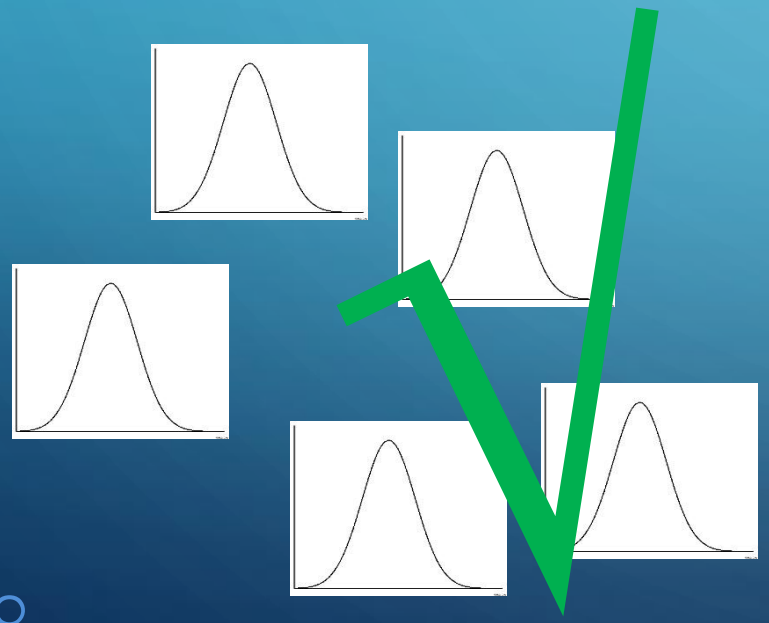
(Mirhosseini et al. 2013)

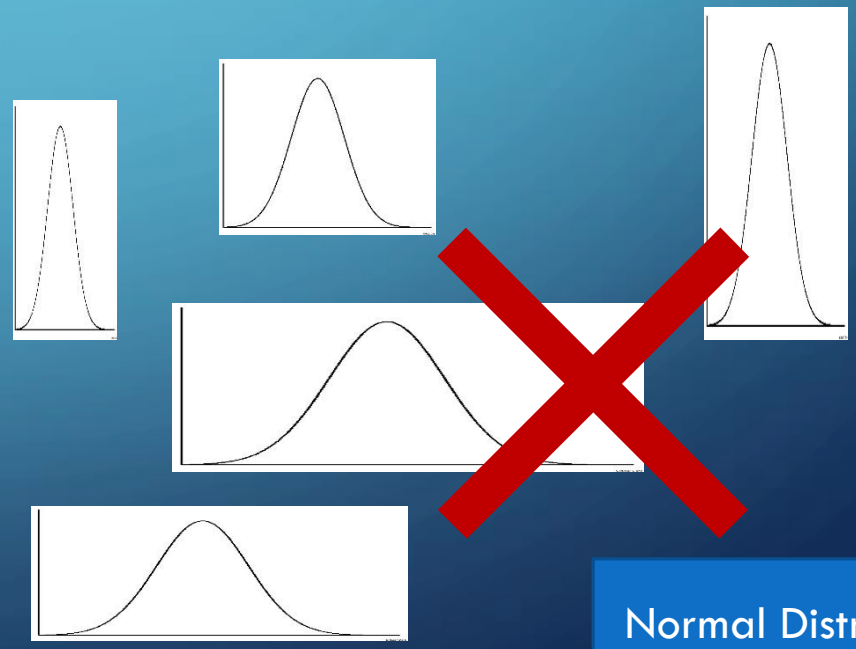
Challenges

- **Sampling deficiencies**
  - **the sample length is not long enough to support reliable statistical analysis** (Bell, 1969; Alila, 1999)

Solution: Regional Frequency Analysis

- **Substitute space for time by using observations from other local gauges to compensate the short time-series records**
- **Identify homogenous samplings: critical to obtain a satisfactory solution** (Schaefer, 1990; Hanel Martin *et al.*, 2009; Mirhosseini *et al.*, 2013; Zhu *et al.*, 2013).





Normal Distribution is used for illustration

Challenges of Climate Model Evaluation

Assessment is conducted within areas of particular interest (e.g. coastal California, Mississippi Valley)

the homogeneity of heavy precipitation patterns?

Model uncertainty in the U.S?

- **An objective, quantitative, repeatable, and transparent approach to identifying homogeneous regions for the evaluation of model performance across the U.S.**

Objective

- Evaluate the simulation of extreme rainfall events at the regional scale for the continental of U.S. from different combinations of GCMs (or driving models) and RCMs in NARCCAP
- Spatial Variability
  - Model performance
  - Climate change on extreme rainfall events

Data & Models

Sources	Spatial Resolution	Temporal Resolution	Time Period
North American Regional Reanalysis (NARR)	32 km	3 hour	1979 - 2000
North American Regional Climate Change Assessment Program (NARCCAP)	50 km	3 hour	Historic: 1968 – 2000
			Future: 2038 - 2070

Models from NARCCAP

RCM	Driving Model				
	NCEP	CCSM	CGCM3	GFDL	HadCM3
CRCM	√	√	√		
ECP2	√			√	
HRM3	√			√	√
MM5I	√	√			√
RCM3	√		√	√	
WRFG	√	√	√		
Time Slice		√		√	

- Emissions scenario: A2
- NCEP is available in historic

Methods

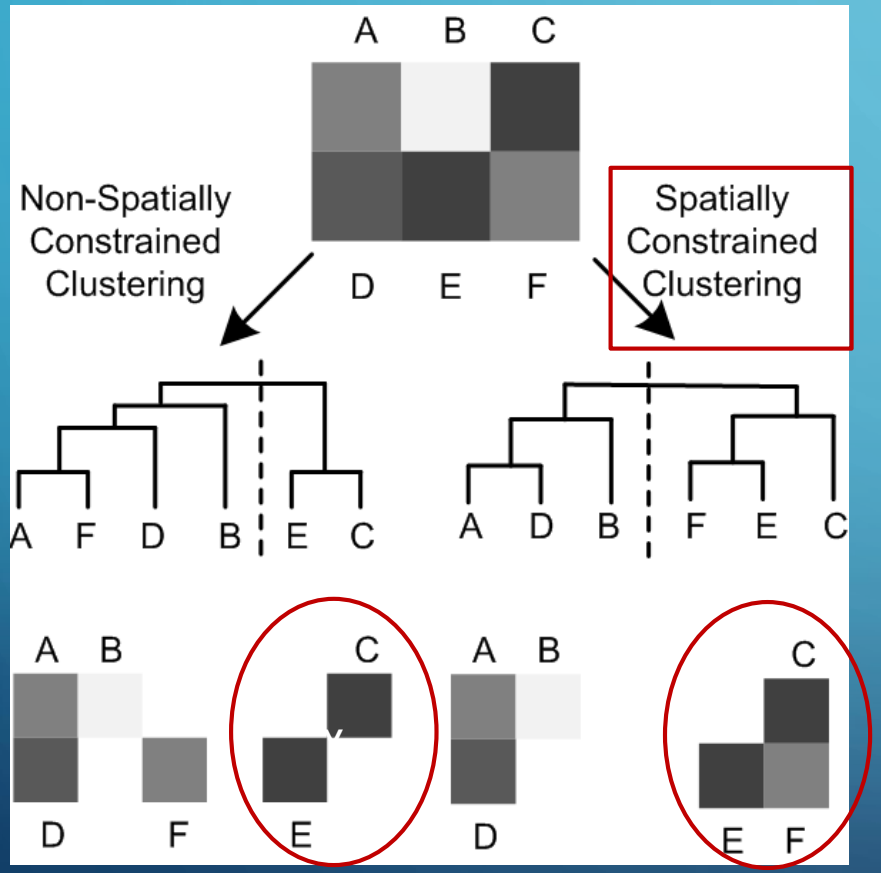
- Annual maximum 24-hour rainfall
- Regionalization:
  - homogeneous Regions (grid clusters) from NARR having similar annual maximum rainfall patterns

North American Regional Reanalysis (NARR)

Regionalization

- Each Grid
  - annual maximum 24-hour rainfall in about 30 years
- Similarity (or dissimilarity) between each pair of grids
  - Anderson–Darling distance placing more weight on observations in the tails of the distribution
- Regionalization: grid clusters
  - having similar annual maximum rainfall patterns measured by Anderson–Darling distance
  - Spatial contiguity

REDCAP (Regionalization with Dynamically Constrained Agglomerative Clustering And Partitioning)



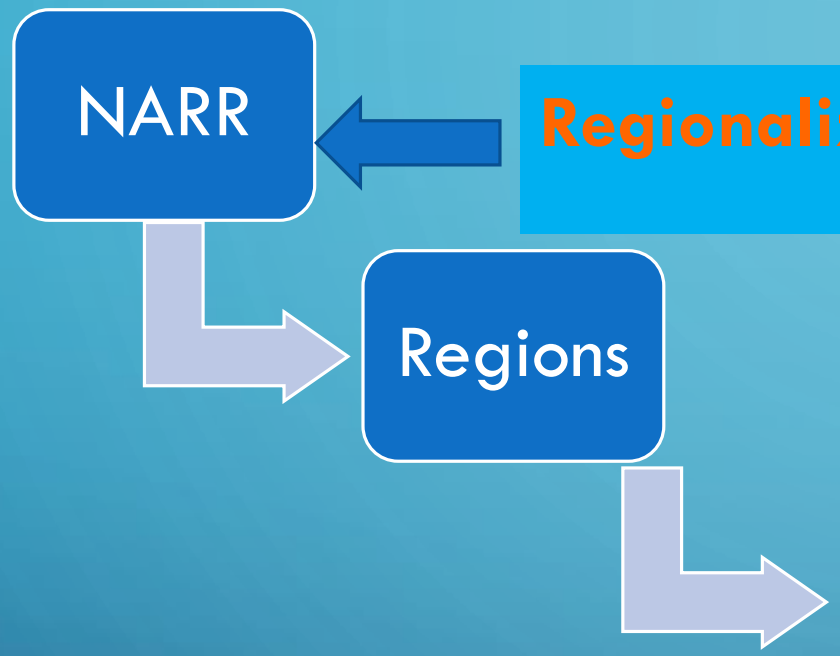
- Common: grid clusters with similar annual maximum rainfall pattern
- Uniqueness of REDCAP: spatially contiguous grids

(Guo, 2008; Kupfer et al. 2012)

Similarity of colors: Similarity of annual maximum rainfall patterns measured by Anderson–Darling distance

http://www.spatialdatamining.org/

Methods



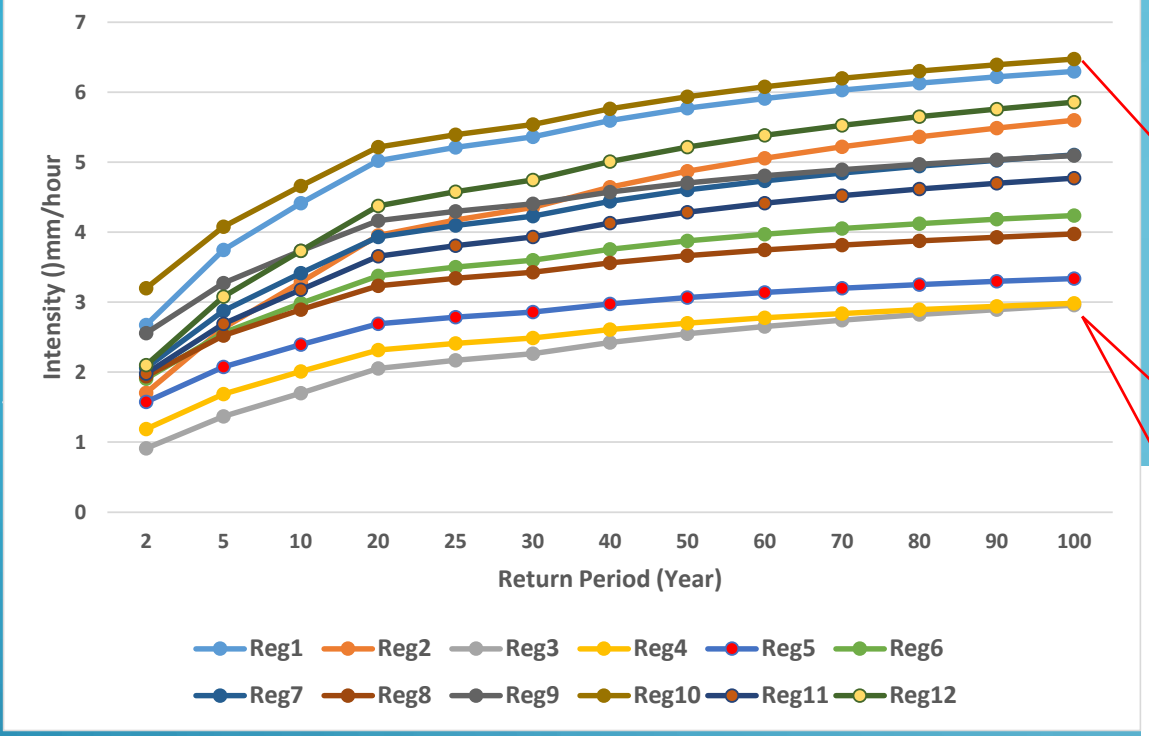
North American Regional Reanalysis (NARR)

North American Regional Climate Change Assessment Program (NARCCAP)

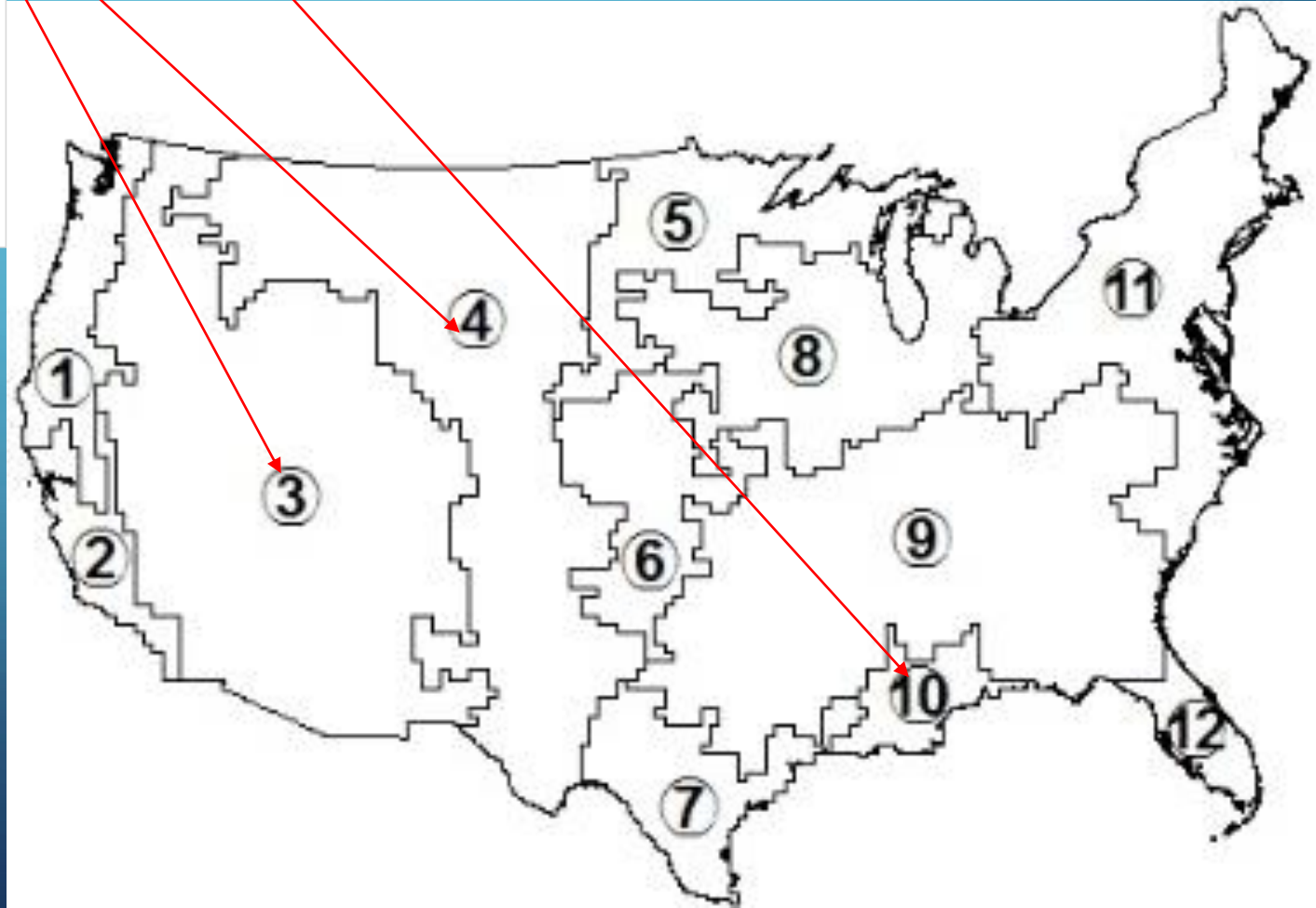
- IDF: Intensity-Duration-Frequency curves

- Assessment: IDF from NARCAPP in historic vs. IDF from NARR
- Future change: IDF from NARCAPP in future adjusting the bias in historic vs. IDF from NARR

Regions from NARR

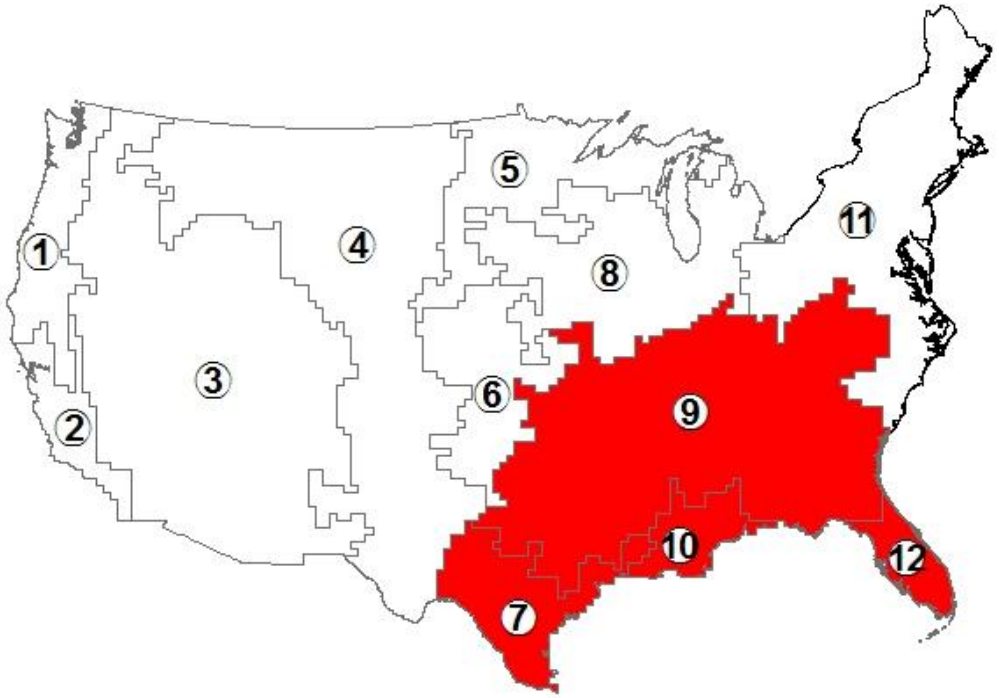


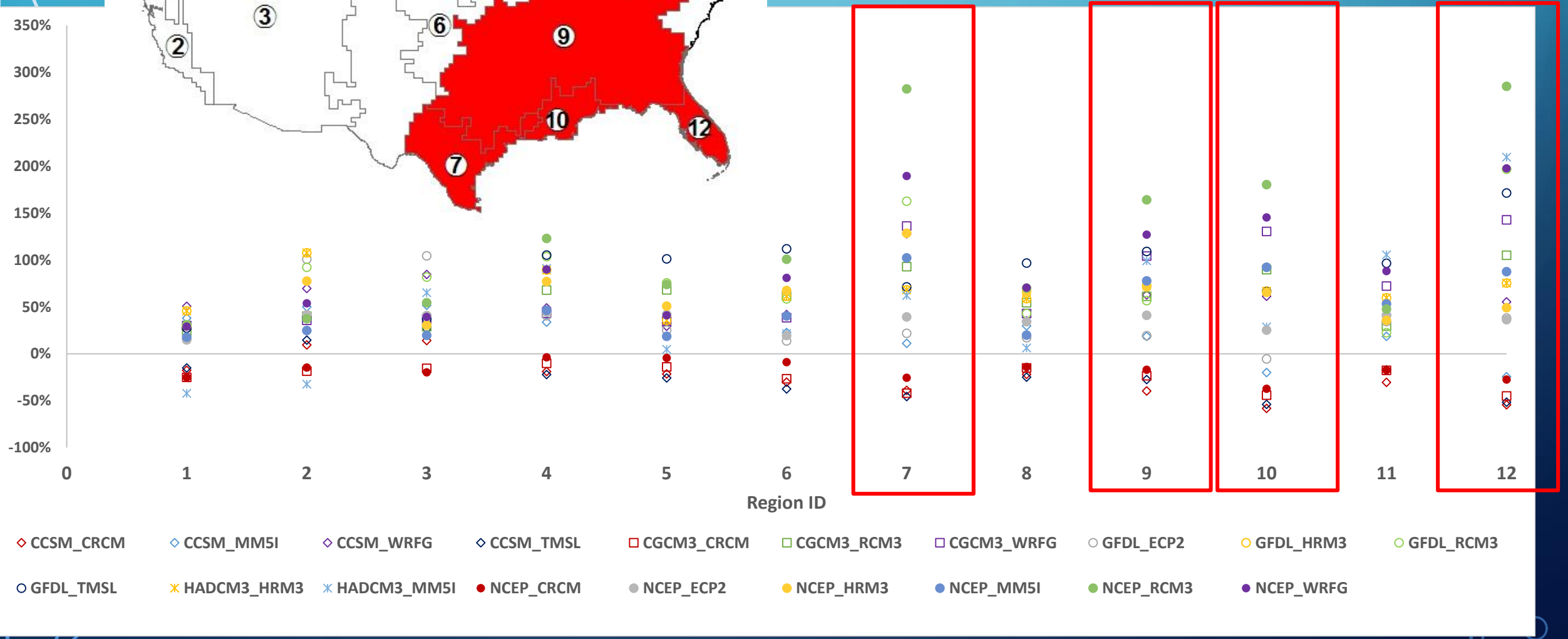
1. Pacific Northwest
2. Mediterranean California
3. Intermontane West
4. Rockies
5. Northwoods
6. Central Plains
7. Texas Plains
8. Great Lakes
9. Eastern Interior
10. Gulf Coast
11. Northeast
12. Florida



Results

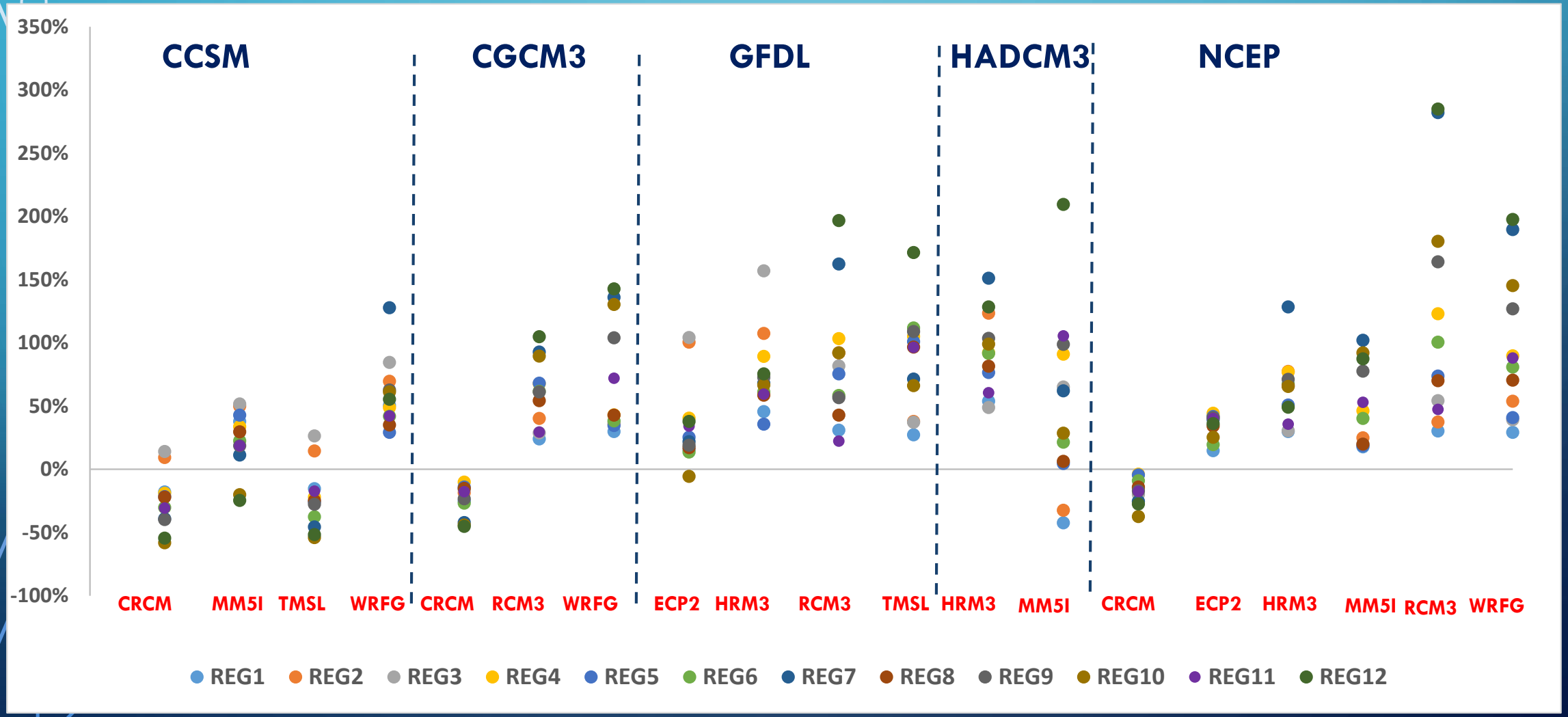
Performance by Region





Results

Performance by Model



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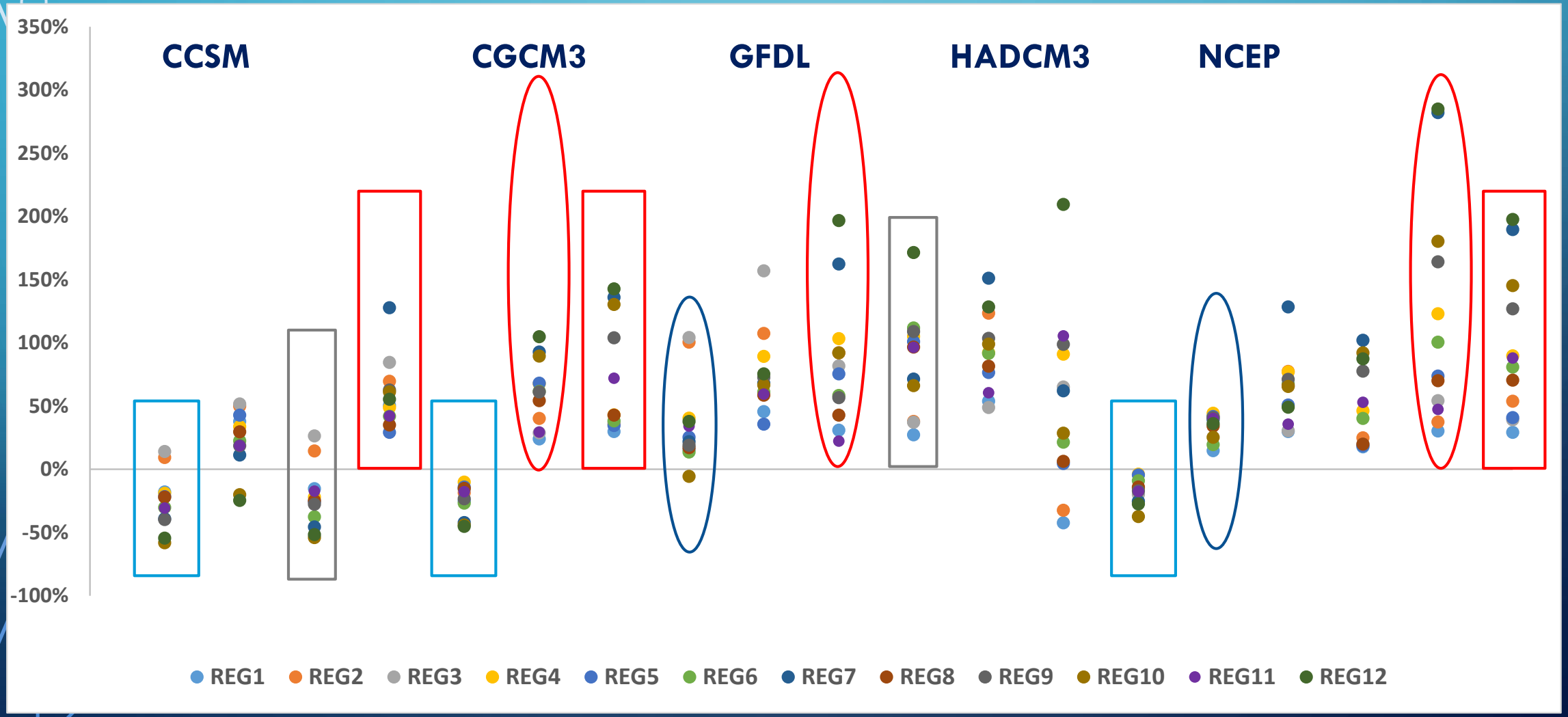
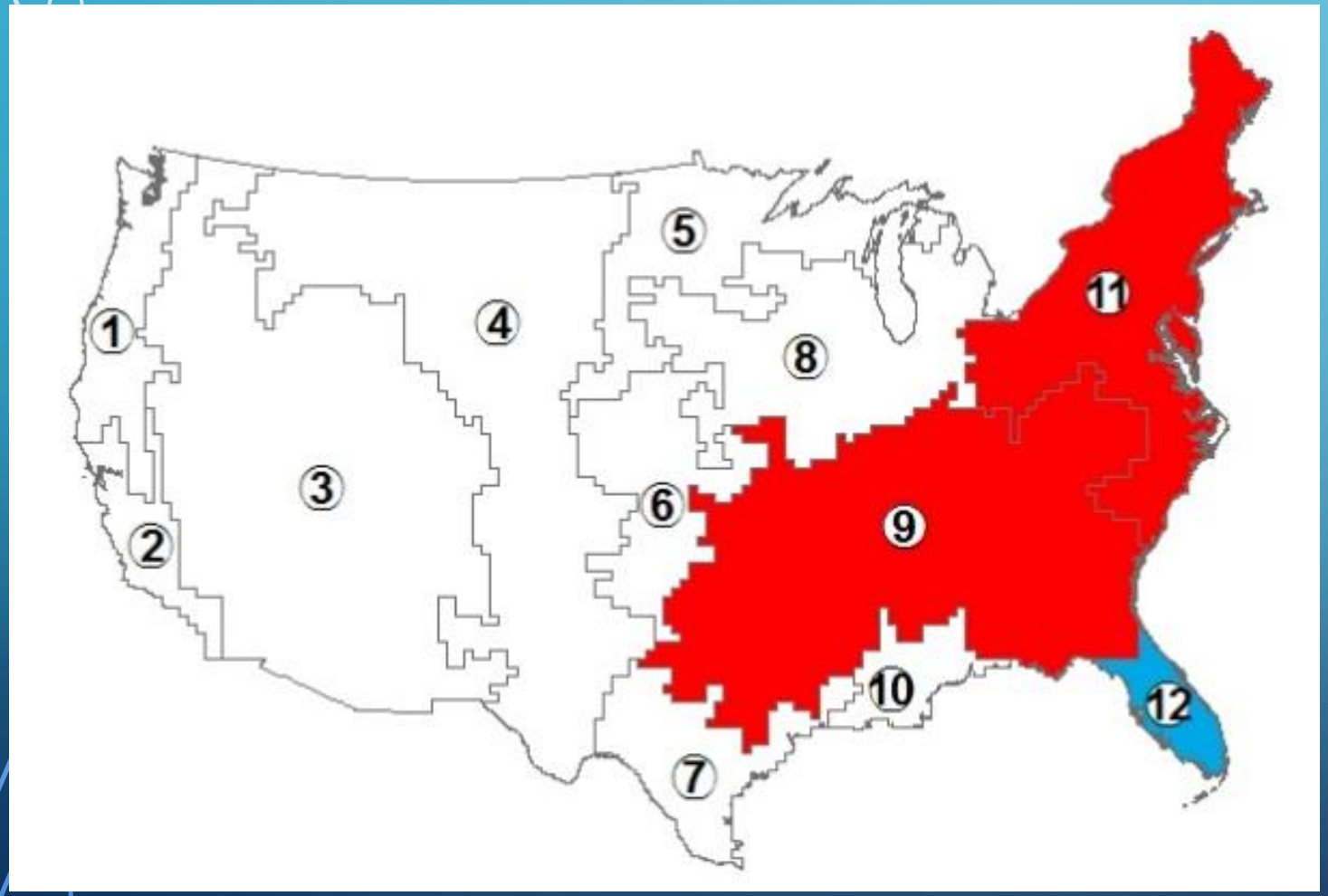


Future Change in Selected Regions



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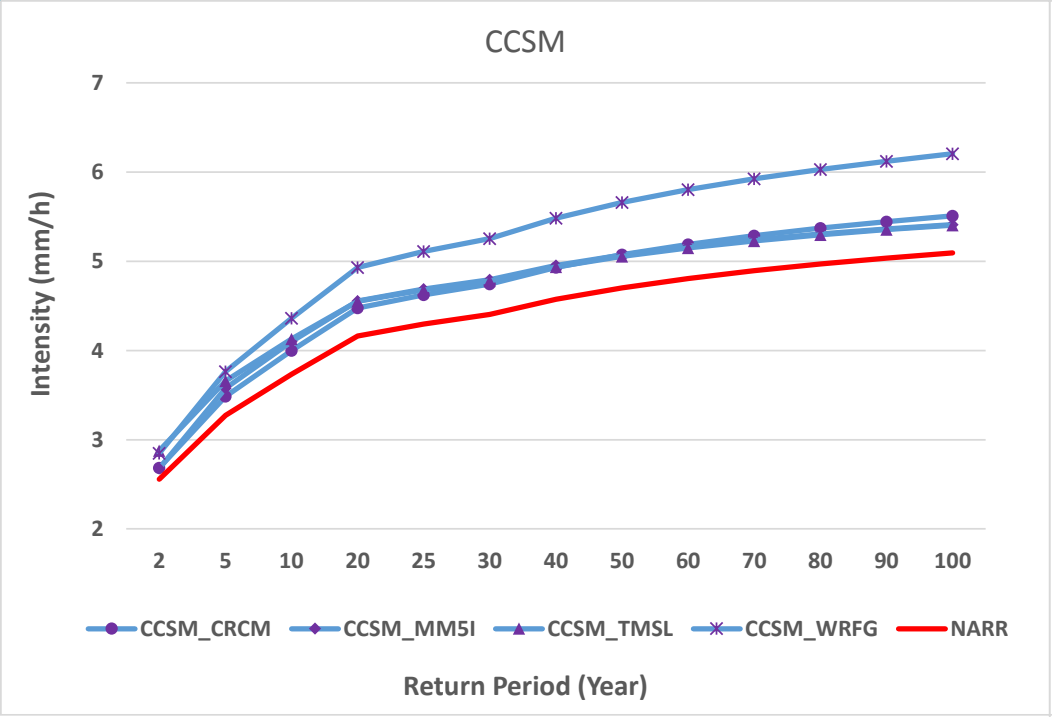
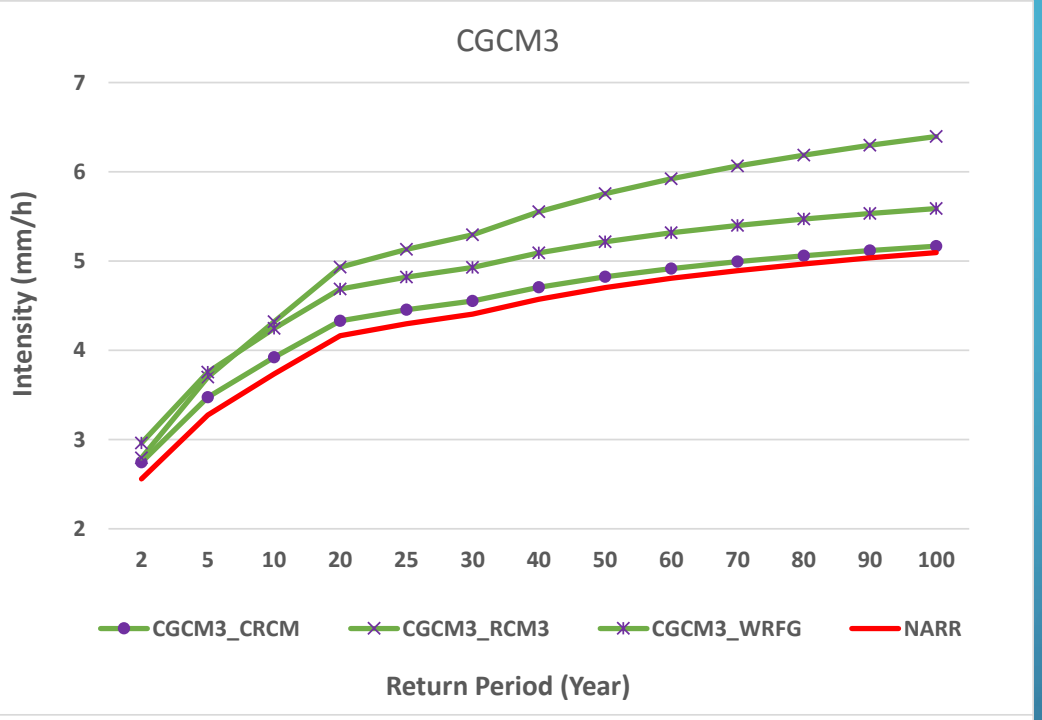
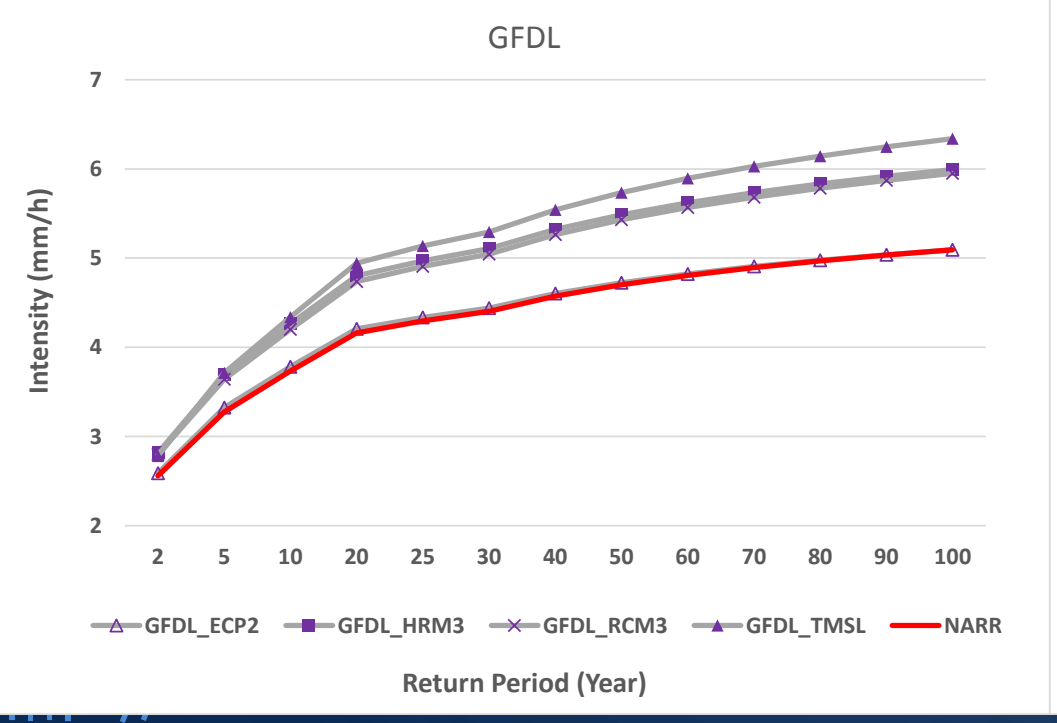
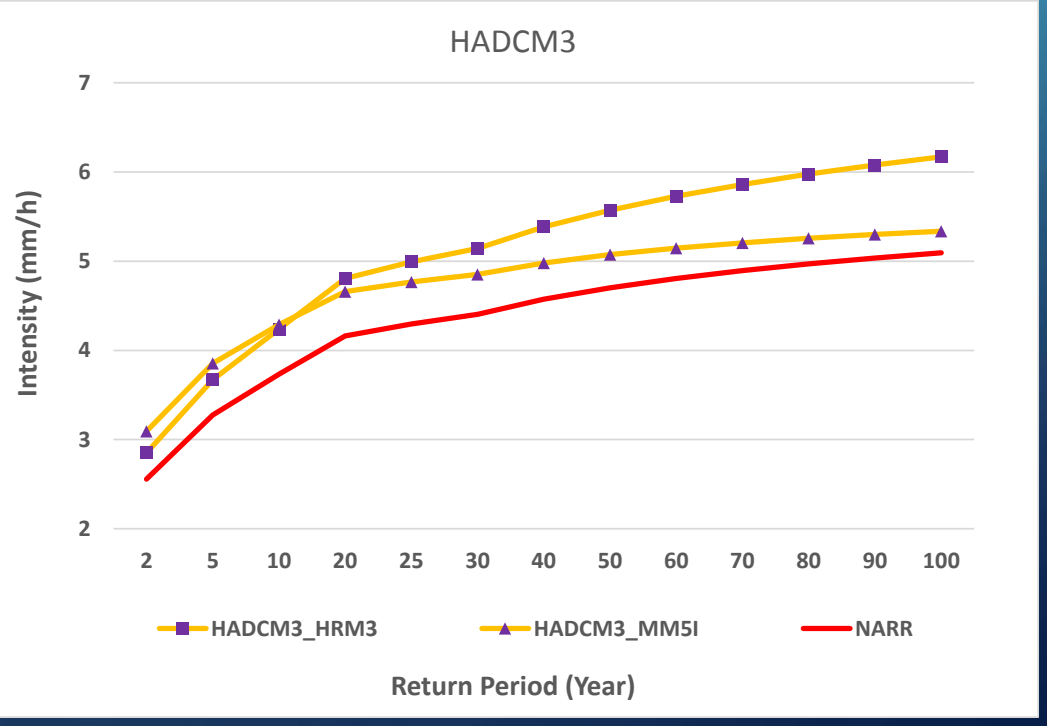






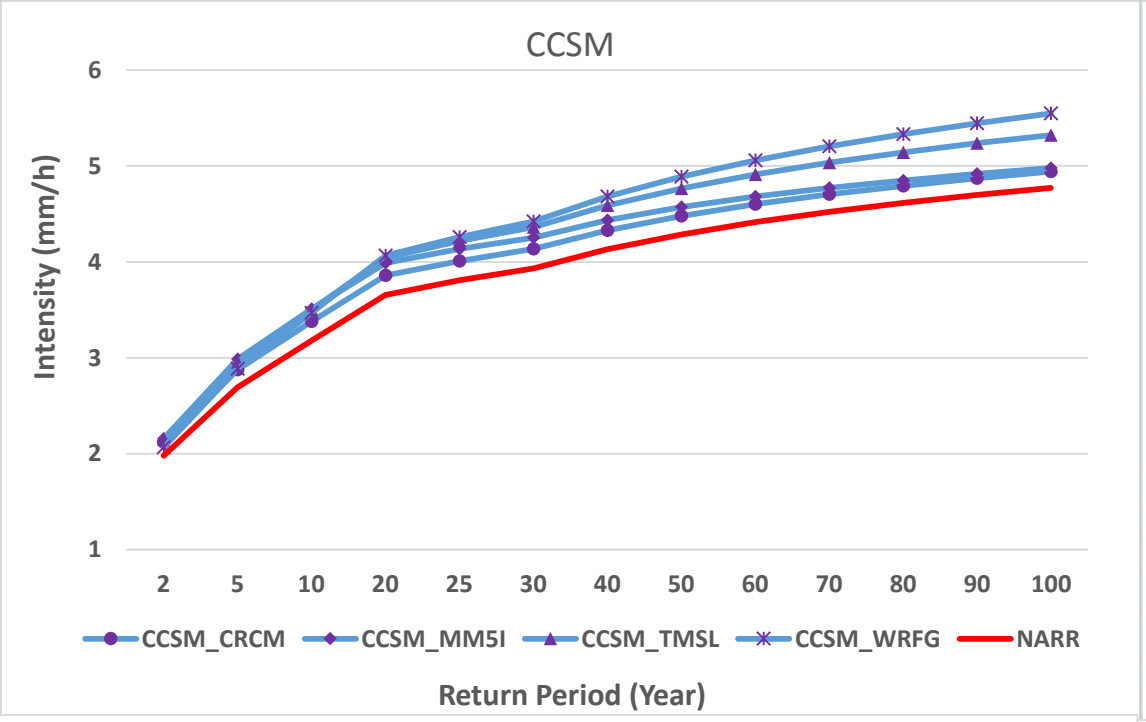


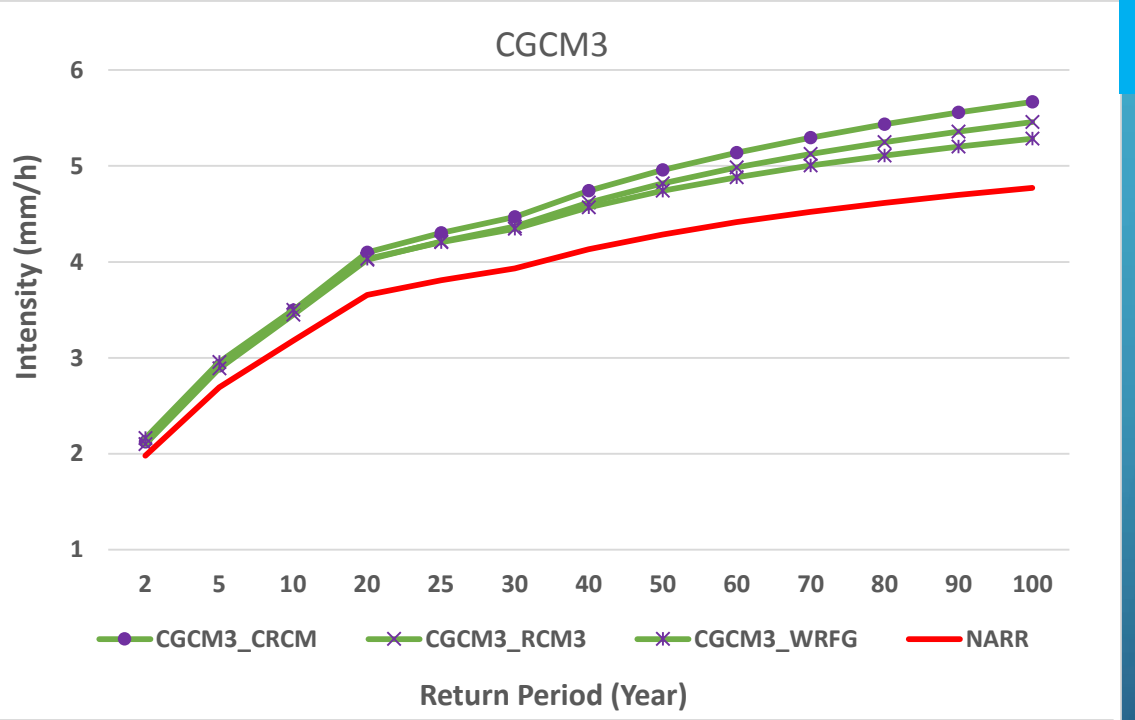
Region 9

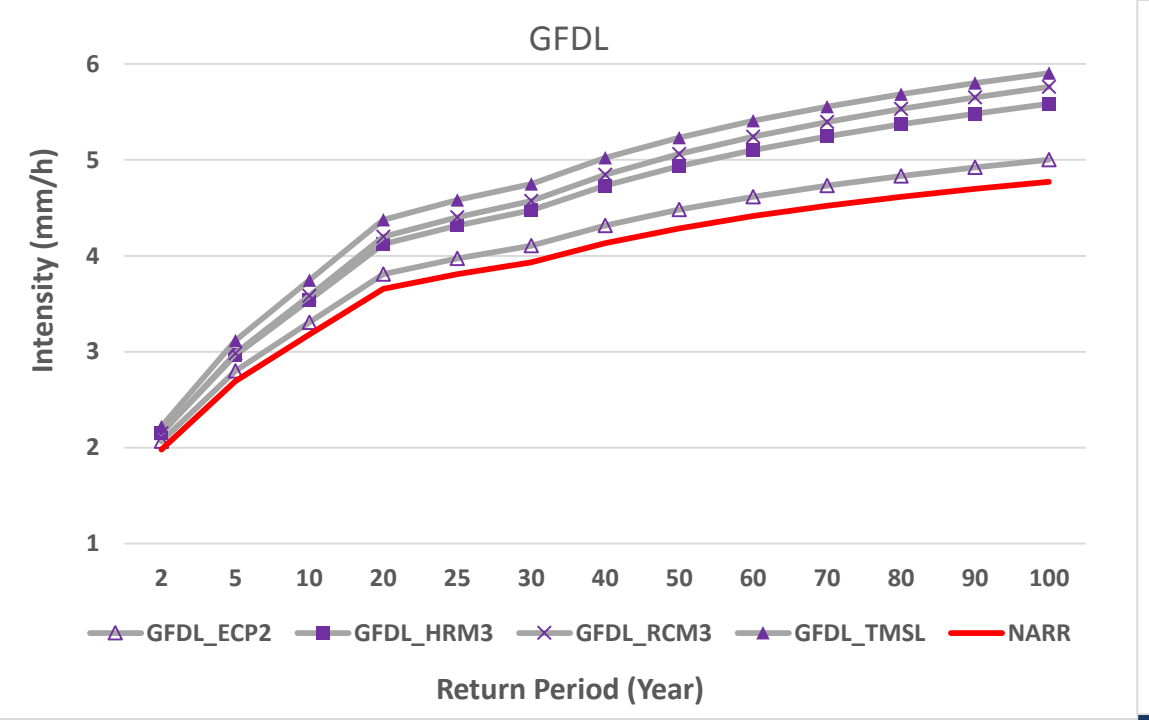
Eastern Interior

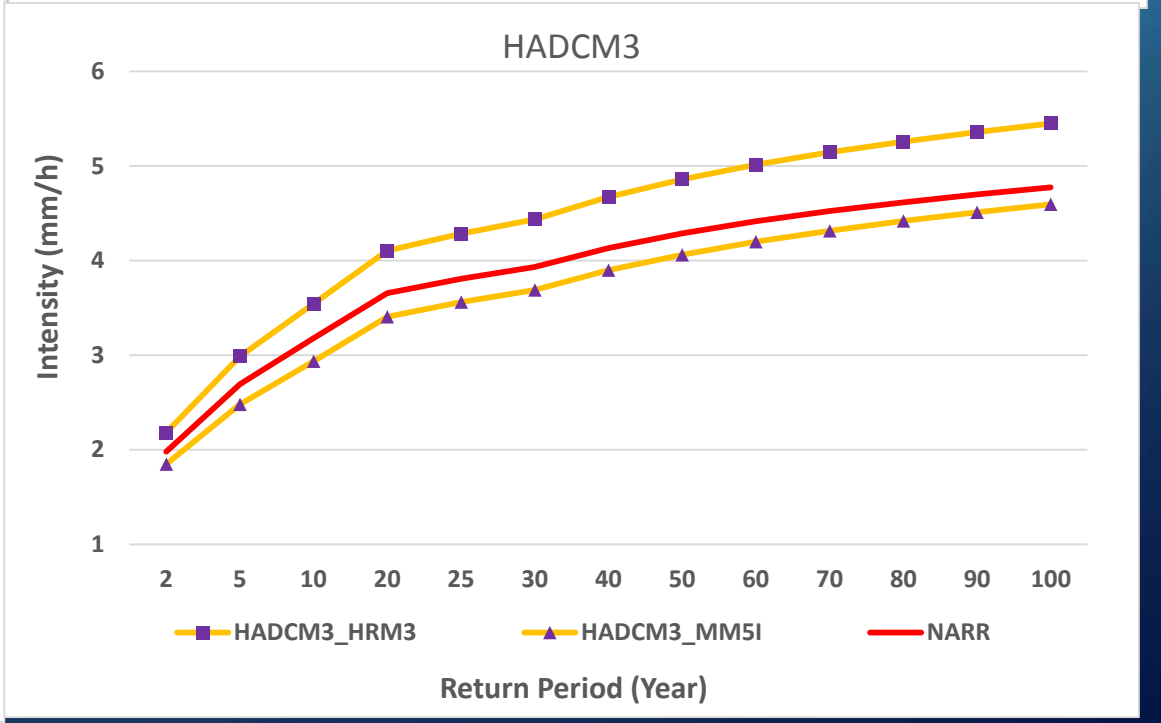
Results

Region 11 North -east









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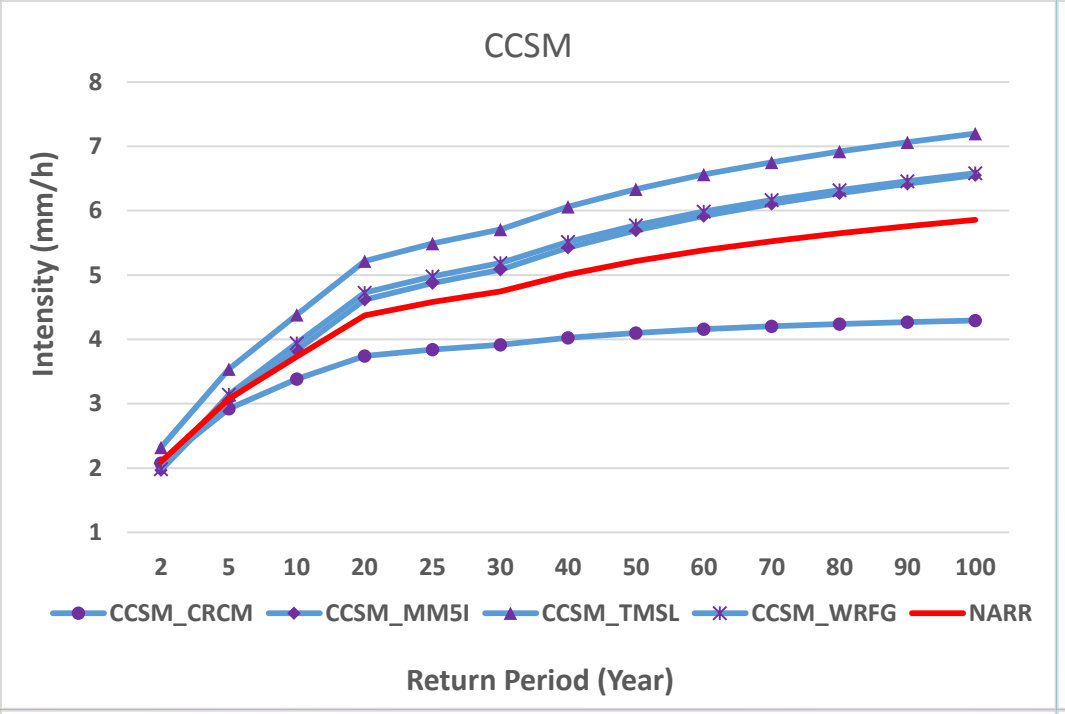

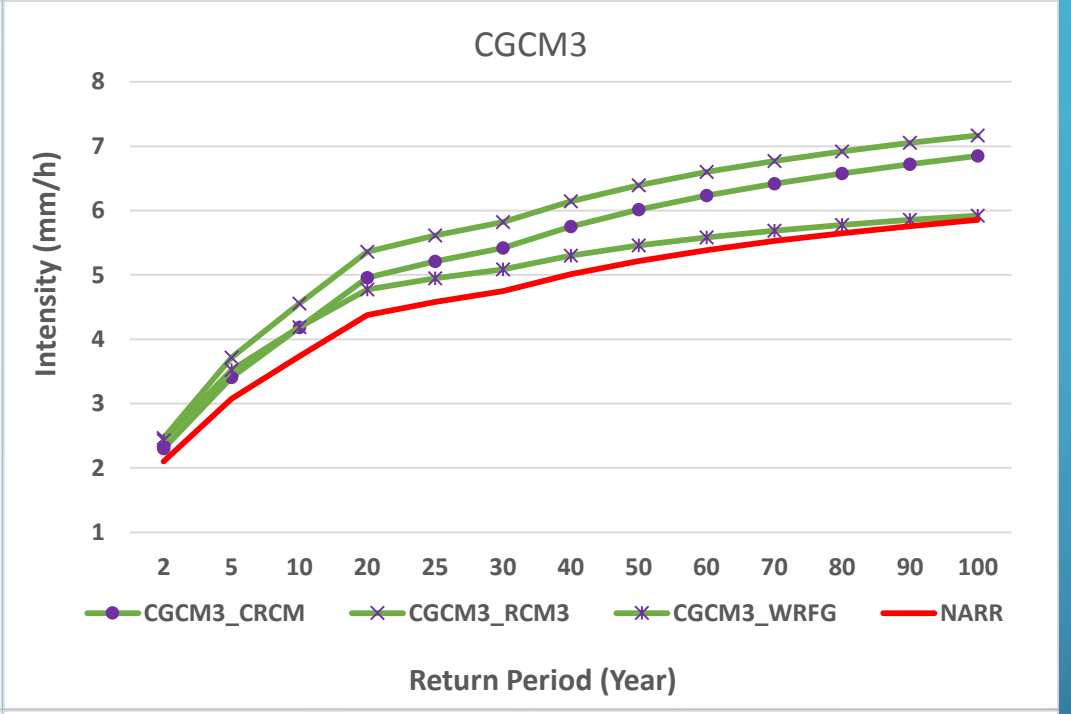

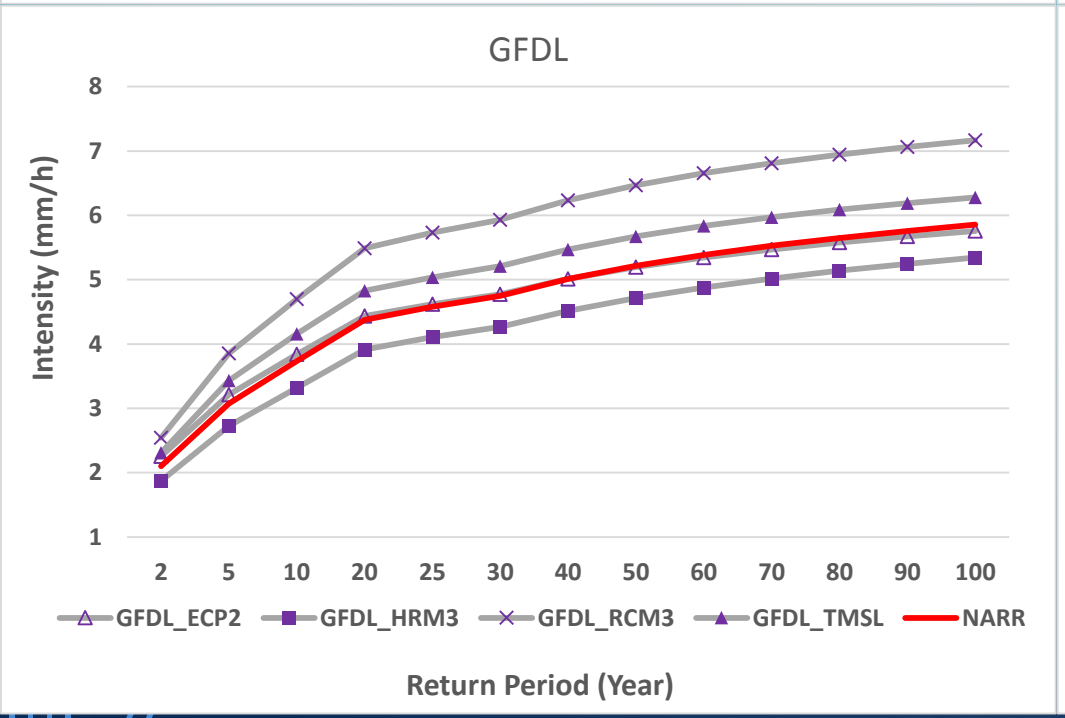

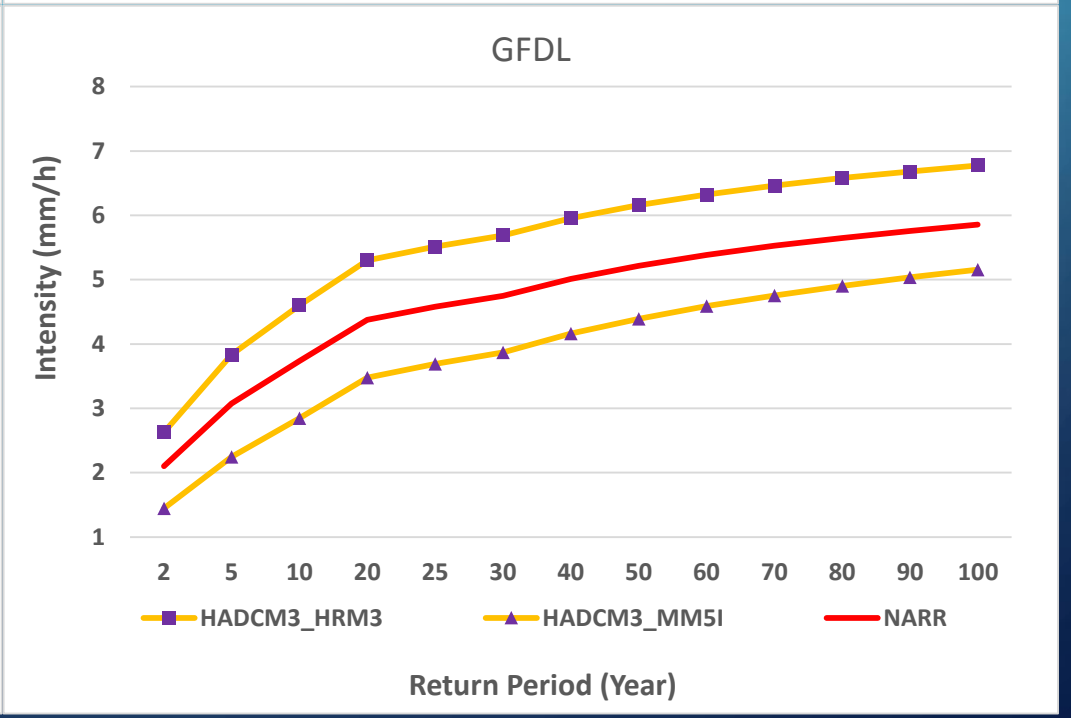

Region 12

Florida

Summary

- Assessment
  - Regions: Some models perform poorly along southeastern coast (i.e., Texas Plains, Eastern Interior, Gulf Coast, and Florida)
  - GCMs: CCSM is the best driving model
  - RCMs: CRCM and ECP2 perform best; RCM3 and WRFG perform worst; Performance of others depends on the driving GCM
- Future
  - In most regions, most models suggest intensified 24 hour rainfall events (exceptions: decreases in Florida and Texas Plains)

Discussion

- Regionalization method
  - Homogenous regions make the fitting of IDF curves more reliable
  - Reveal spatial variability of model performance