Extreme Precipitation Intensities for a Range of Durations from NARCCAP Simulations

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Introduction

- Tools for engineering and planning need to incorporate climate information
- Design storms (e.g. 100-year, 6-hour storm), used in engineering, are usually calculated from the annual maximums of observed precipitation data sets using extreme value distributions.
- Here, design storm intensities are calculated for a range of durations (3-, 6-, 9-, 12-, 18-, 24-, 48-, and 96- hours) and return periods (2- and 100-year) from NARCCAP data sets using regional frequency analysis (Hosking and Wallis 1997) and the Generalized Extreme Value (GEV) distribution.

Data

- Hourly precipitation data from the National Climatic Data Center (NCDC) for seven locations (http://www.ncdc.noaa.gov/oa/climate/stationlocator.html), all station data are first-order airport stations:
  - Portland, OR (61 years)
  - Las Vegas, NV (61 years)
  - Denver, CO (61 years)
  - Dallas, TX (36 years)
  - Minneapolis-St. Paul, MN (61 years) (St. Paul)
  - Orlando, FL (68 years)
  - Albany, NY (61 years)
- For the following data sets, data from the grid at each of the above seven locations, and the eight surrounding grids, totaling nine grids per location.
- Seven NARCCAP (Mearns et al. 2007) data sets:
  - HRM3_HADCM3 (HAD_HAD)
  - WRFG_CCSM
  - CRCM_CCSM
  - CRCM_CGCM3
  - RegCM3_CGCM3 (RCM3_CGCM)
  - RegCM3_GFDL (RCM3_CGCM)
  - Timeslice_GFDL (Time_GFDL)
- NCEP/NCAR North American Regional Reanalysis Data (1979-2000)(NARR) (Mesigner et al. 2006)
- Each data set has different spatial resolutions: NARR (32 km), NARCCAP (50 km), and NCDC (point), and depth-area relationships should be considered.
- Recent works have shown that NARR data may not always reflect observations (e.g. Sun and Barros 2010).

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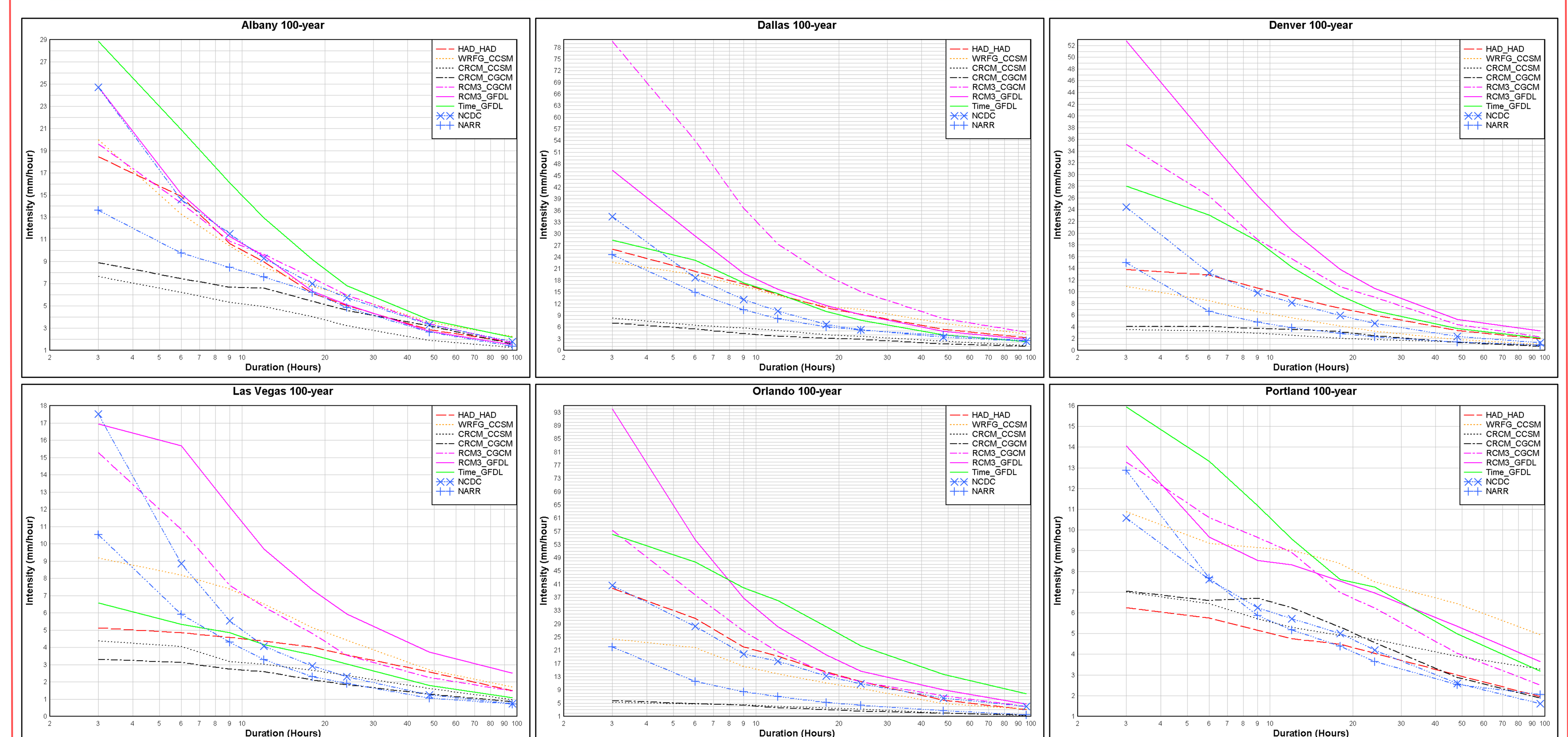
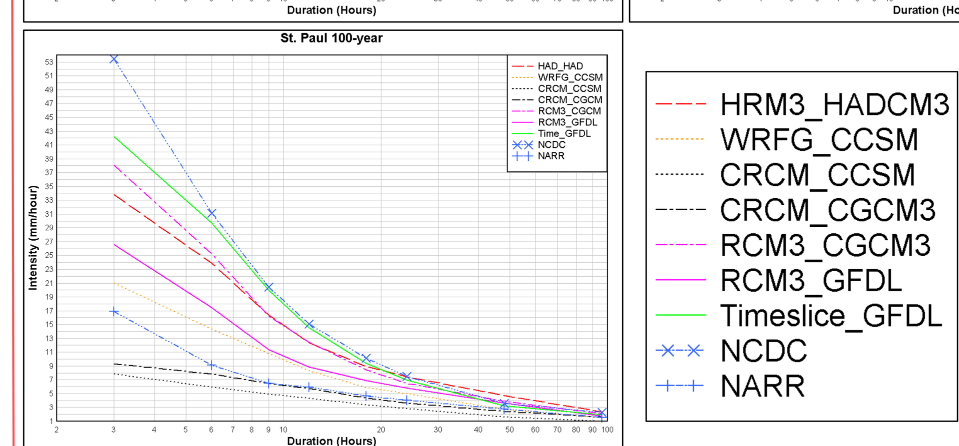
Method

- In regional frequency analysis (RFA), data from surrounding locations (or in this case, grids) are used to increase the sample size of a distribution for extreme value analysis.
- For a location and duration, a grid's annual maximums (e.g. peak intensity for a given duration for each year) are divided by their respective median, and the annual maxima for all nine grids are combined (the grid at each location plus the eight surrounding grids).
- The GEV distribution is fit to each set of standardized annual maxima and the 2- and 100-year return values are calculated. The standardized values are rescaled to the grid of interest using the median for that grid and duration to obtain the design storm intensities.

Results - Historical Simulations





Plots of design storm intensities for all durations (3-, 6-, 9-, 12-, 18-, 24-, 48-, and 96-hours) for the 100-year storm (2-year storm is not shown). Each line is for one data set. Observations are indicated by blue lines with symbols. X-axis is duration in hours. Y-axis is intensity in millimeters/hour.

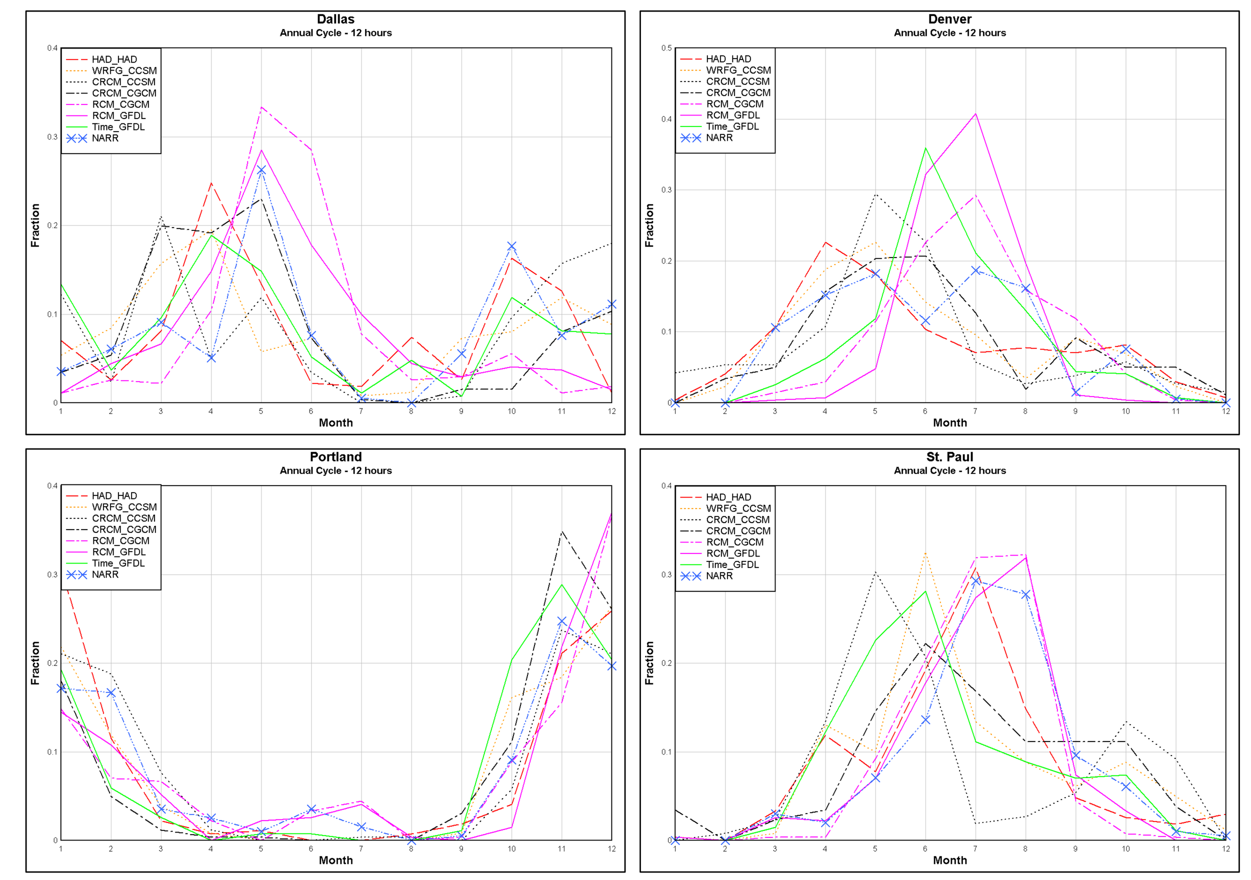
- Across all seven locations for the 100-year and 2-year storms:
  - CRCM_CGCM3 and CRCM_CCSM intensities are at relatively lower values for most durations compared to other data sets.
  - Intensities for both RegCM3 data sets and the Timeslice_GFDL data set are often at relatively greater values for many durations.
  - Trends are similar for the 2- and 100- year storms.
  - Differences in slopes across durations may be associated with seasonal differences in extremes.

Average Percentage Difference from NARR Values (2- and 100- year storms)

Data Set	Shorter Durations (3-, 6-, 9-, and 12- hours)							Longer Durations (18-, 24-, 48, and 96- hours)						
	Albany	Dallas	Denver	LV	Orlando	Port	SP	Albany	Dallas	Denver	LV	Orlando	Port	SP
CRCM_CCSM	-0.1	-0.4	-0.3	0.3	-0.4	0.5	-0.3	-0.2	-0.5	-0.5	-0.2	-0.6	0.0	-0.3
CRCM_CGCM	0.0	-0.4	-0.1	0.0	-0.4	0.2	-0.1	-0.1	-0.6	-0.4	-0.4	-0.6	0.0	-0.2
HAD_HAD	0.2	0.4	1.0	0.8	0.9	0.0	0.5	0.5	0.4	0.6	0.0	0.9	-0.2	0.8
NCDC	0.2	0.1	0.5	0.1	1.1	0.0	0.4	0.6	0.4	0.7	0.3	1.0	0.0	1.2
RCM3_CGCM	0.3	0.9	1.5	0.8	1.0	0.5	0.4	0.5	1.3	1.7	0.5	1.2	0.4	0.9
RCM3_GFDL	0.2	0.3	2.3	1.8	1.6	0.8	0.2	0.5	0.5	3.0	1.2	2.2	0.3	0.4
Time_GFDL	0.5	0.2	1.2	0.5	2.5	0.9	0.4	1.1	0.3	1.8	0.0	1.9	0.7	1.2
WRFG_CCSM	0.3	0.5	0.1	1.1	0.6	1.2	0.0	0.5	0.3	0.0	0.4	0.5	0.5	0.2

Average percentage difference from NARR values. A single average difference value was calculated across all durations for both storm types for a given location. The percentage difference between intensities was separated into shorter (3-, 6-, 9-, 12-) and longer (18-, 24-, 48, 96-) durations.

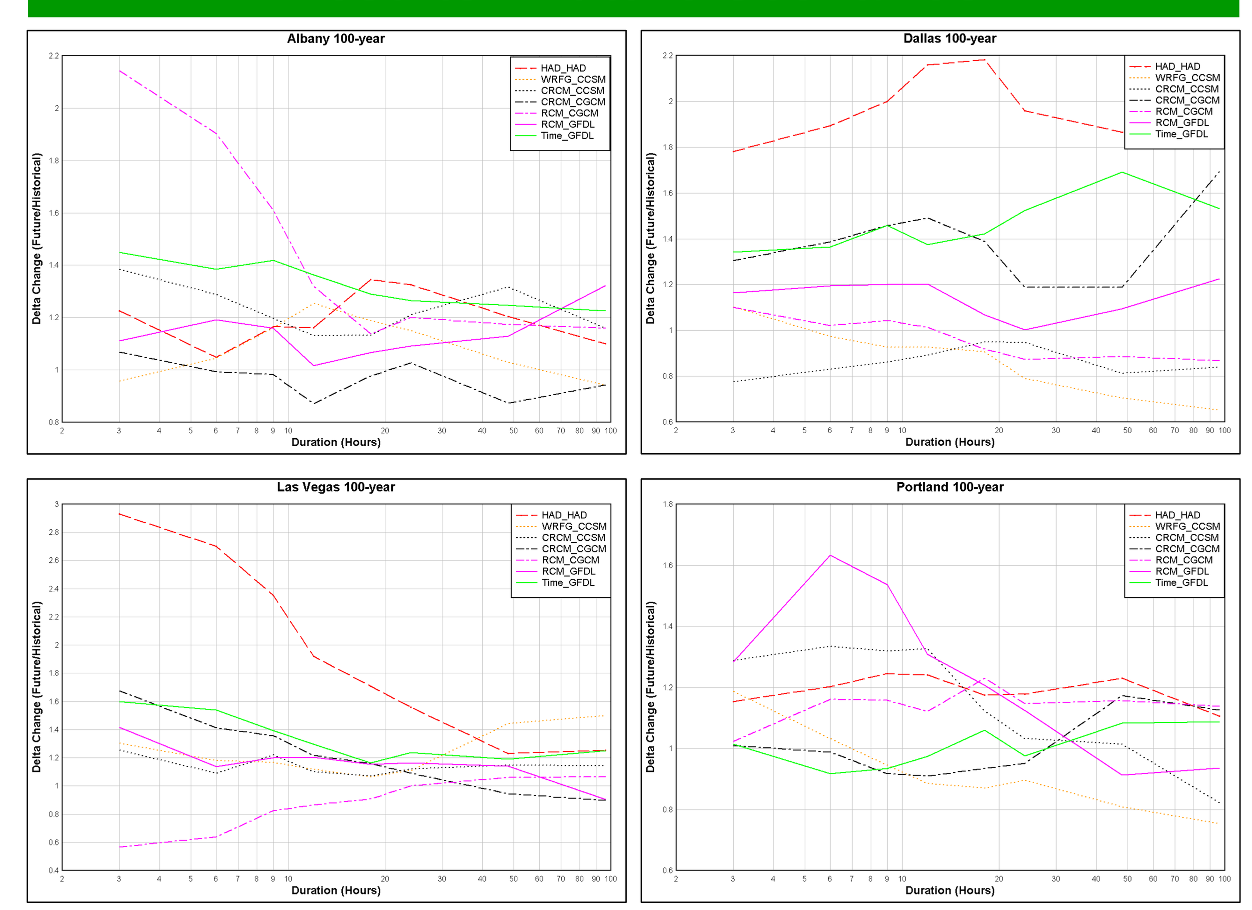
- Most data sets generally have extremes greater than corresponding NARR values; CRCM data sets are the exception to this.
- The annual cycles of annual maxima (3-, 12-, 24-, and 96- hour durations) for all nine grids were examined to better characterize differences among data sets→



Annual cycle of annual maxima for all nine grids of the 12-hour duration for historical data. The y-axis is fraction of the total annual maxima.

- Across all locations for the annual maxima of 3-, 12-, 24-, and 96-hour durations:
  - There is a tendency for RCM3 data sets to have a relatively higher percentage of maximums in the summer/fall months as compared to other NARCCAP data sets.
  - All other data sets are more variable in their annual cycle pattern depending upon duration and location.
  - There is some persistence across durations, possibly due to the dominance of large values that would influence all durations.

Results - Future Scenarios



Projected change in storm intensities (future/historical) for all durations. Each line is for one data set. X-axis is duration in hours. Y-axis is delta change (future intensity/historical intensity).

Summary Table of Delta Change Factors

Data Set	Albany			Dallas			Denver			Las Vegas			Orlando			Portland			St. Paul		
	Mn	Max	Min	Mn	Max	Min	Mn	Max	Min	Mn	Max	Min	Mn	Max	Min	Mn	Max	Min	Mn	Max	Min
CRCM_CCSM	1.2	1.4	1.0	0.9	1.0	0.8	1.0	1.1	0.8	1.1	1.3	0.9	0.9	1.1	0.5	1.1	1.3	0.8	1.2	1.4	1.1
CRCM_CGCM	1.0	1.2	0.9	1.3	1.7	1.1	1.0	1.4	0.9	1.1	1.7	0.9	1.1	1.2	1.0	1.0	1.2	0.9	1.1	1.2	0.8
HAD_HAD	1.1	1.3	1.0	1.6	2.2	1.2	0.9	1.1	0.8	1.6	2.9	1.2	1.3	1.6	1.0	1.2	1.3	1.1	0.9	1.1	0.6
RCM3_CGCM	1.3	2.1	1.1	1.1	1.7	0.9	1.5	2.0	1.1	0.9	1.1	0.6	1.7	2.3	1.4	1.1	1.2	1.0	1.3	1.5	1.0
RCM3_GFDL	1.1	1.3	1.0	1.1	1.3	1.0	1.1	1.4	1.0	1.1	1.4	0.9	1.5	1.7	1.3	1.1	1.6	0.9	1.3	1.6	1.0
Time_GFDL	1.2	1.4	1.0	1.2	1.7	0.9	1.2	1.4	0.9	1.3	1.6	1.1	0.8	1.1	0.6	1.0	1.1	0.9	1.0	1.2	0.7
WRFG_CCSM	1.1	1.3	0.9	1.0	1.2	0.7	1.0	1.3	0.9	1.1	1.5	0.7	1.1	1.3	0.9	0.9	1.2	0.8	1.2	1.4	1.1

Table of mean (mn), maximum, and minimum delta change values (future intensity/ historical intensity) for each location. The mean is the average change among all durations for both the 100- and 2- year storm for that location.

- Across all locations.
  - Delta change factors most often fall between 0.8 and 1.6.
  - Changes tend to be more substantial for the 100-year storm as compared to the 2-year storm.
  - Largest positive changes tend to be associated with the HAD_HAD, RCM3_CGCM3, and RCM3_GFDL models.
  - Trends in the 100-year and 2-year storm are sometimes not the same.
- The annual cycles of delta change factors were also examined and across all locations:
  - There is little convergence among data sets for substantial deviations from 0.0.
  - For a given month, changes rarely exceed 0.1/-0.1.

Summary

- For historical data, CRCM data sets tend to have relatively lower intensities across all durations; all other data sets produced intensities that exceeded NARR intensities for most durations.
- RCM3 and Timeslice_GFDL data sets tend to produce the highest intensities. Walker et al. (2009) studied the RegCM3 model and found biases in extreme daily precipitation in the Western and Southeastern United States, associating the biases with excessive surface/low-level winds and biases in circulation/moisture fields, respectively.
- RCM3 data sets produce a greater percentage of annual maximums in the late summer/fall months as compared to other data sets.
- Delta change factors fall between 0.8 and 1.6 for most durations and locations.

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