Analysis of Changes in Location-Specific Extreme Precipitation Using Dynamical Downscaling

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Introduction

Climate models indicate that an increase in global mean temperature will lead to increased frequency and intensity of storms of a variety of types. Through this research, we will determine if rain gage data from Stockholm, Sweden (Figure c) indicate an increase in extreme precipitation over two thirty year periods. We first compare the results of the statistical analysis of the observational data with results for the same period produced by the DOE-NCAR Community Earth System Global Model (CESM-DOE-NCAR GCM). The AWRA Weather Research Forecasting Regional Model (WRF-AWRA RCM) is then compared against the CESM GCM and gage data to determine the most reliable model.

Methods & Materials

- Generalized Extreme Value Theory (Fig 1)

  $Y_T = -ln(ln(T/T-1))$

  $X_T = u + aY_T$

- Generalized Pareto (Fig 2)

  Generate parameters from gpfit (scale and shape)

  $X_T = \sigma(((1/T)^{-\Upsilon}-1)/\Upsilon)$

- Log Pearson Type III (Fig 3)

  Calculate mean, standard deviation, skew kurtosis

  $Y_T = y_{bar} + K_T s_Y$

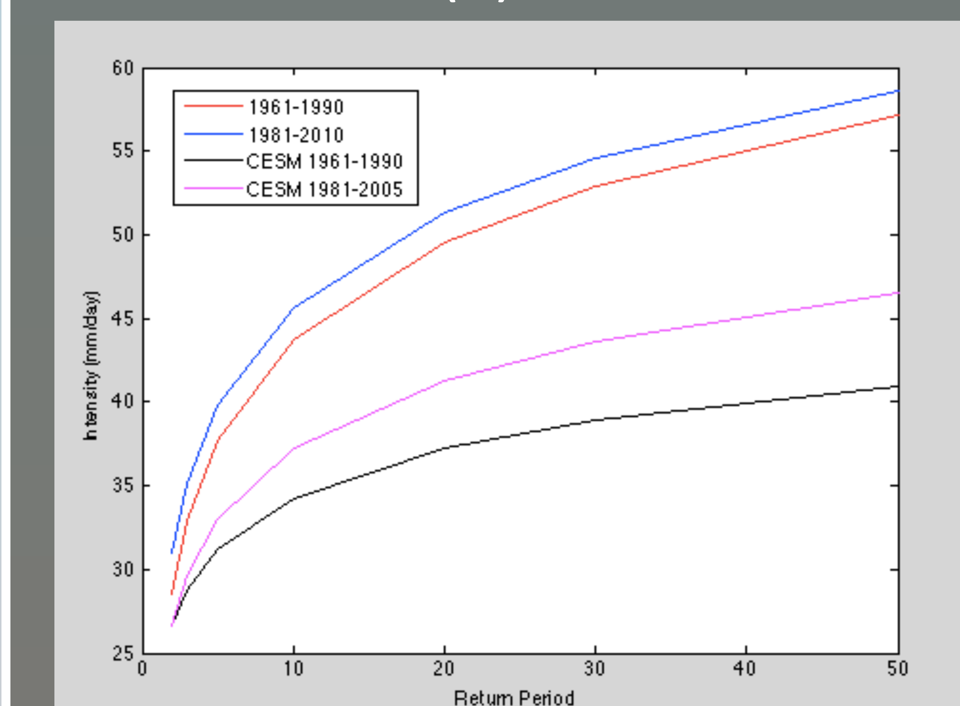
  $X_T = 10^\wedge Y_T$

- CESM DOE-NCAR GCM
- WRF-ARWA RCM

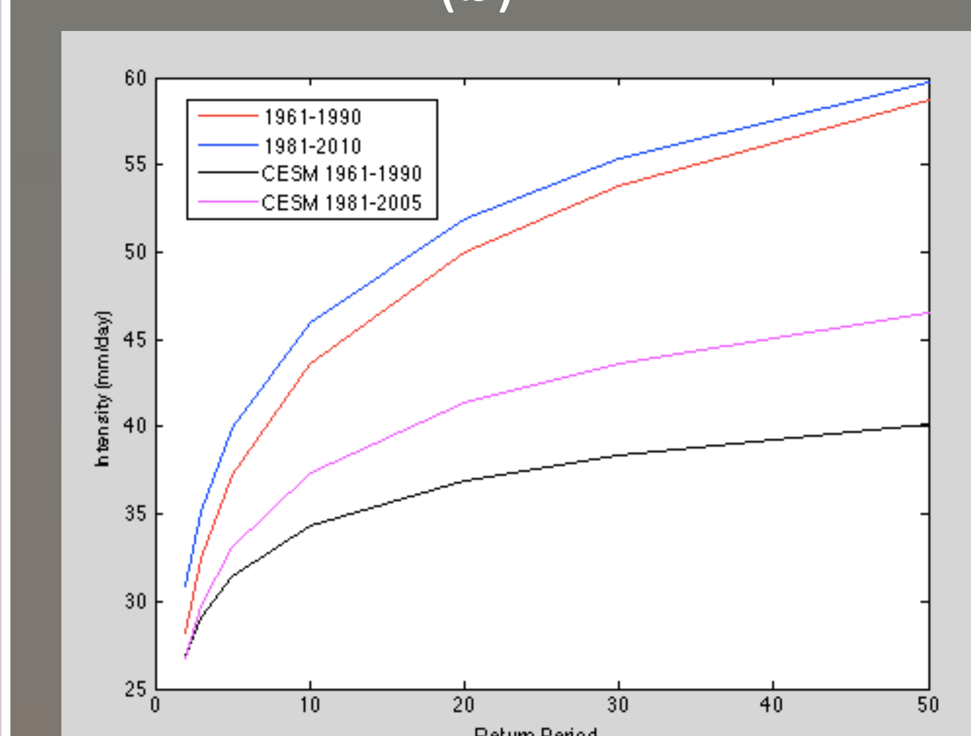
Results

The study conducted on rain gage data from Stockholm, Sweden over two thirty year periods, 1961-1990 and 1981-2010 indicate an increase in the frequency of intense precipitation for both rain gage data and GCM data using Generalized Extreme Value Theory (GEV) and Log Pearson Type III (LP3) (Figures a and b) for the second thirty year period, 1981-2010. GCM data analyzed using General Pareto (GP) indicates similar results, however, rain gage data analyzed in GP show more frequent intense storms for the first thirty year period (Figure d). Increased frequency of intense precipitation agree with previous research findings (e.g. Frich et al. 2002, Lehtonen et al. 2013, Sun et al. 2007). Year 1961 rain gage data has an extreme outlier which could be responsible for the results produced by GP. Another finding is that GCMs underestimate intensity (Figures a,b,d). GCM results underestimate rainfall due to their inability to capture regional characteristics and climate phenomena (Lehtonen et al., 2013). However *Lehtonen et al., 2013* determined that there was no difference between GCMs and RCMs in their tendency towards more extreme precipitation. Therefore, despite its inaccuracy, it is still useful in analyzing trends in extreme precipitation. Lastly, this research indicates that LP3 performs the best in determining the intensity and return (Figures e,f). A study performed by *Guttman., 1999* analyzing statistical distributions for the Standardized Precipitation Index determined that Log Pearson III produced the fewest number of differences between regional and candidate models, most symmetrical pattern of differences, and exhibited the least spatial and temporal invariant differences. Based on these criteria, it was determined that LP3 was the "best" model which coincides with our findings found in Figures e and f.

(a)

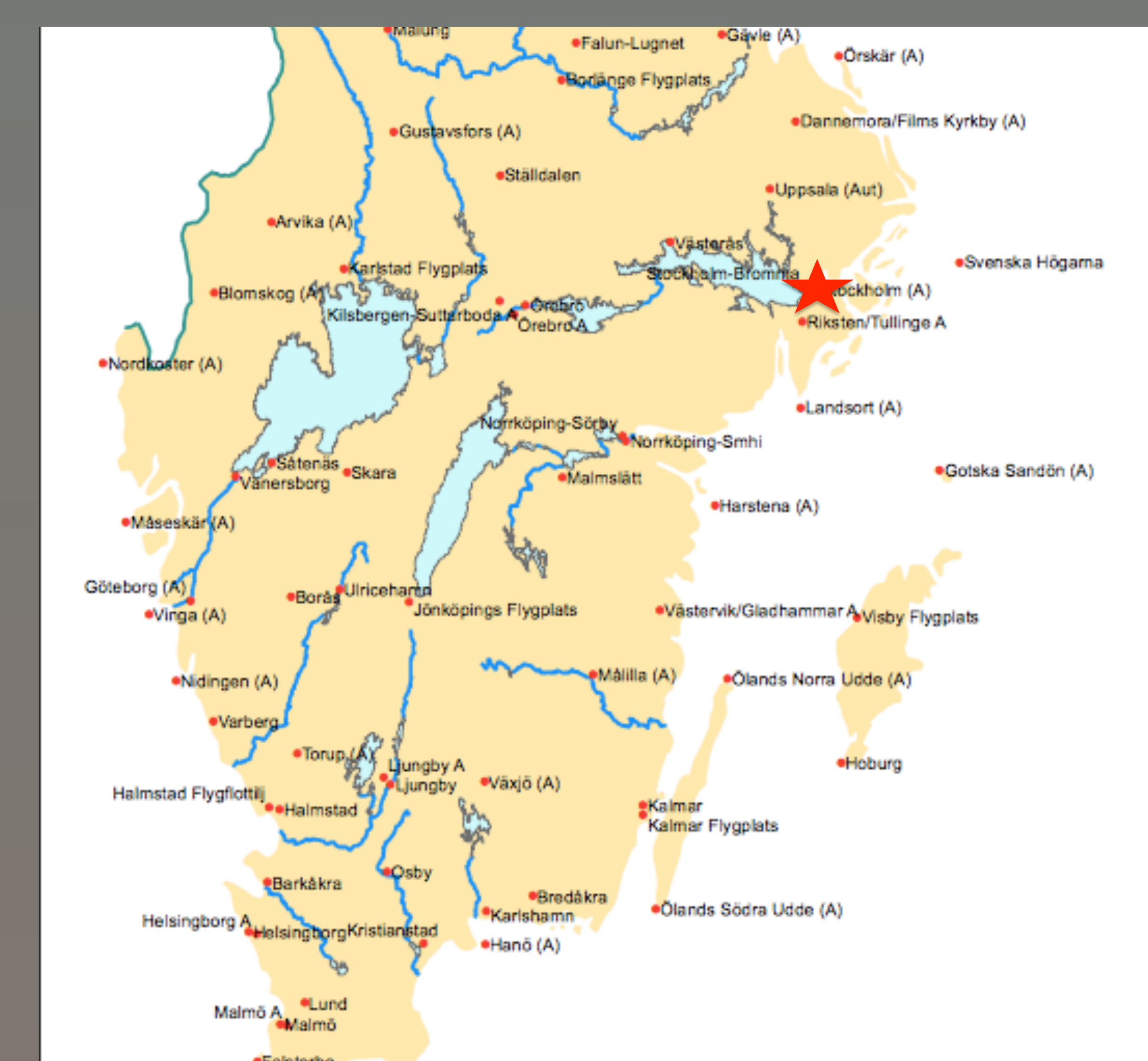


(b)

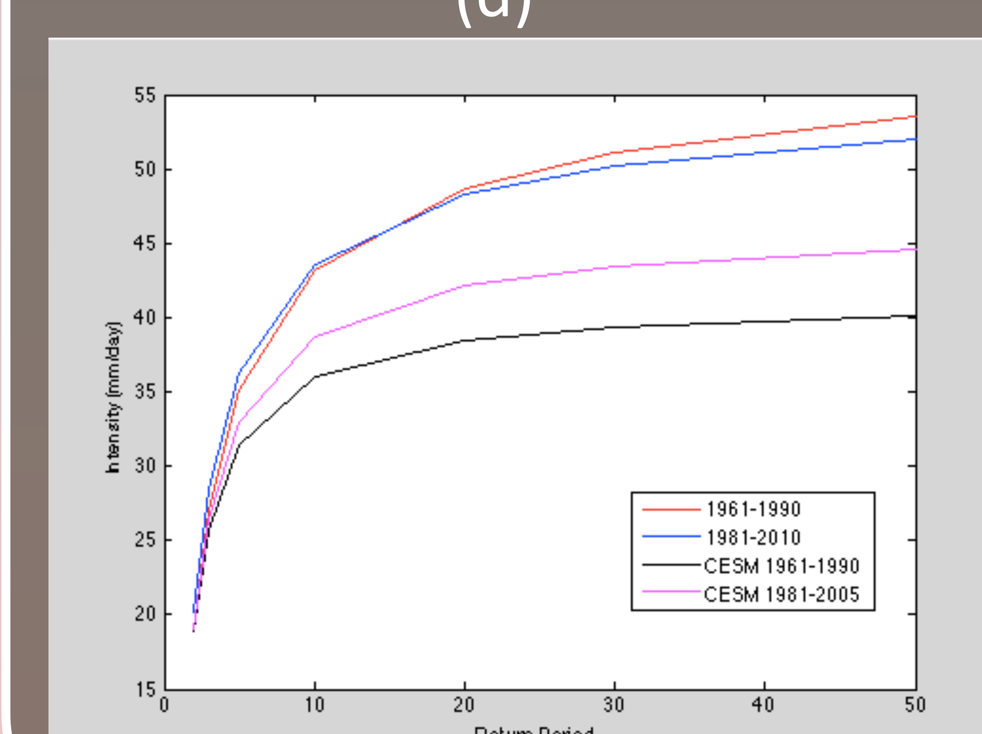


From left to right GEV analysis of rain gage data and CESM GCM data (Figure a). LP3 analysis of rain gage data nd CESM GCM data (Figure b). Map of Stockholm, Sweden, location of rain gage data (Figure c). GP analysis of rain gage data and CESM GCM data (Figure d). Comparison of manual return period calculation against GEV, LP3, and GP for first thirty year period, 1961-1990 (Figure e). Comparison of manual return period calculation against GEV, LP3, and GP for first thirty year period, 1961-1990 (Figure f).

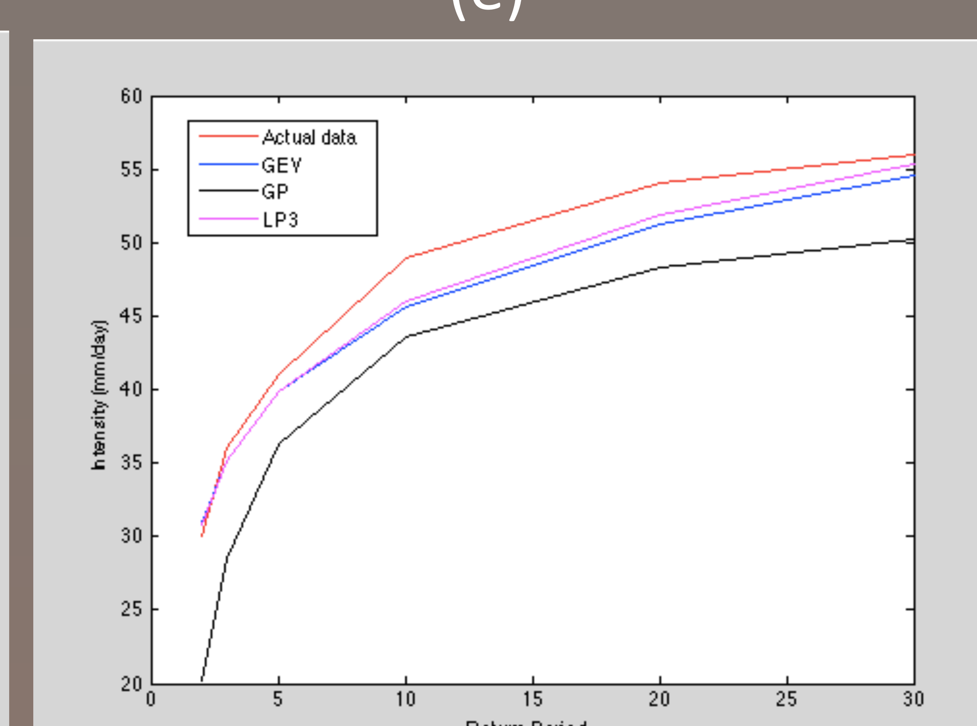
(c)



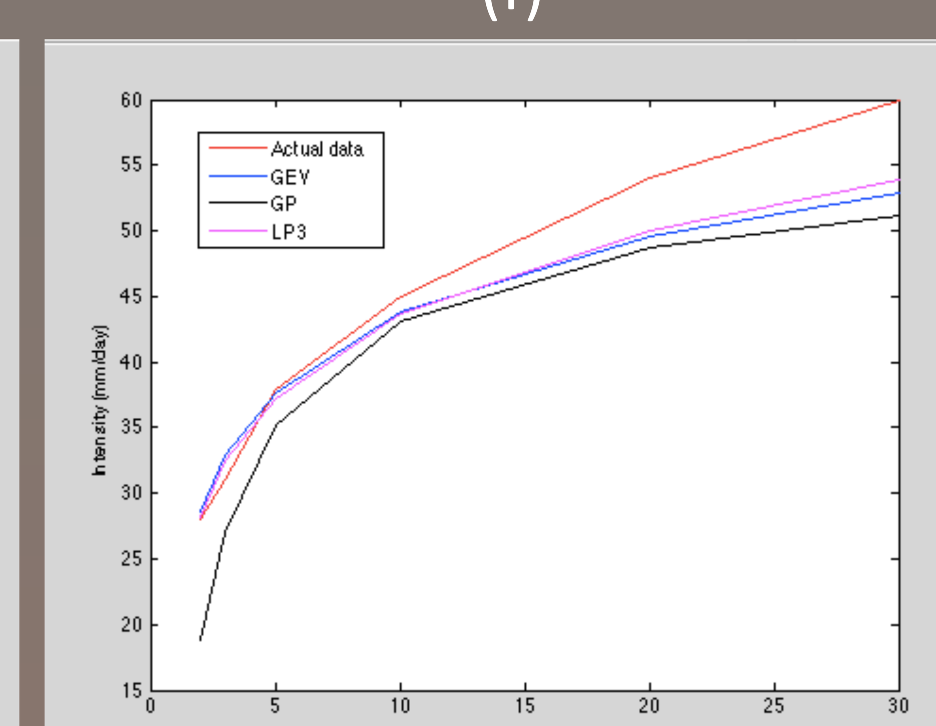
(d)



(e)



(f)



Conclusions

- Increase of frequency of intense precipitation in second thirty year period
- CESM GCM underestimates intensity of precipitation
- Log Pearson Type III distribution estimates intensity and return period most accurately

Continued Research

Future research will produce precipitation data for Stockholm, Sweden from the Weather Research Forecasting regional climate model WRF RCM. With this data we will analyze the WRF RCM data with GEV, LP3, and GP distributions to compare the performance of the WRF RCM against the CESM GCM. Future work could include predicting future frequency of intense precipitation and its impact on water infrastructure.

References

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