The Change in Climate and Extreme Weather in Sweden Based on the d4PDF

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1. Introduction

The climate in Sweden is relatively temperate compared to locations on the same latitudes (55-70ºN) such as Alaska, Siberia and Greenland. The reason for this is the Gulf Stream transporting heat from the Gulf of Mexico to the western coast of Europe. There has been some discussion on the Gulf Stream slowing down in the future due to climate change. However, there are other threats to the stable climate in Northern Europe. It is clear that human activity causes an increase in average temperature which will cause changing regional climates. One aspect of this is how these changes may affect the extreme weather events that are hazardous to human lives and important infrastructure.

The purpose of this study is to investigate the change in climate and the severity and occurrence of extreme events related to temperature and precipitation in Sweden. Studying this provides information about the importance of mitigation and adaptation efforts.

2. Methodology and Data

2.1 Methodology

For this study the database for policy decision-making for future climate change (d4PDF) was used. It consists of global warming simulation outputs from a global atmospheric model, the JMA/MRI-AGCM. MATLAB was used to analyze data from the JMA/MRI-AGCM model and the d4PDF concerning the Swedish region. Firstly, the JMA/MRI-AGCM model was confirmed to accurately represent the present climate in Sweden. Secondly, the d4PDF change for future climate was compared to that of the ensemble used for climate change studies in Sweden by the Swedish Meteorological and Hydrological Institute (SMHI). Lastly, the d4PDF data was studied to determine the present and future conditions for extreme weather events related to temperature and precipitation.

Table 1: Information about the global d4PDF data.

Grid size	60km
Years (Pres. climate)	1951 - 2010
Years (Fut. climate)	2051 - 2110
Members (pres/fut)	100 / 90 members
Total years (pres/fut)	6000 / 5400

2.2 Data

The IPCC has decided on 4 representative concentration pathways (RCPs) for future GHG emissions in the coming century. Of these RCP2.6 is aggressive in limiting GHGes and in RCP8.5 there is a continued increase in yearly emissions, causing an increase in temperature of 4 degrees by the end of the century.[1]

The d4PDF data used in this study was the global data and the information in Table 1 pertains to that dataset. The future climate data has been simulated from 6 different CMIP5 sea surface temperature (SST) warming patterns for a +4K climate. Each modelled SST has been run for 60 years in 15 members after removing the long term trend in the SST and with GHG concentrations equal to year 2090 in the RCP8.5 scenario.[2]

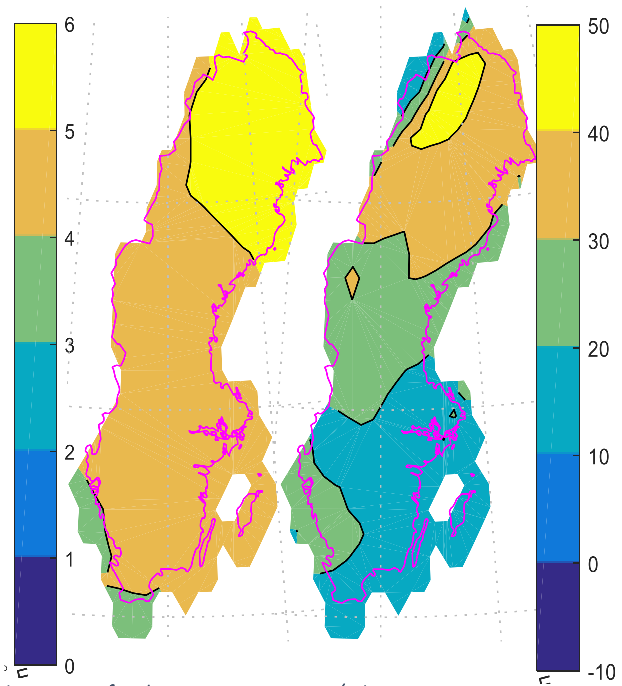

Figure 1: Left: The average autumn/winter temperature increase (deg. C). Right: The average winter/spring precipitation increase from present climate (%).

The SMHI has used a number of models to create an ensemble to estimate the future climate. The ensemble was used to compare future changes. The 9 models used for the RCP8.5 ensemble are: CanESM2, CNRM-CM5, EC-EARTH, IPSL-CM5A-MR, MIROC5, HadGEM2-ES, MPI-ESM-LR, NorESM1-M and GFDL-ESM2M.[3]

3. Results and Discussion

3.1 Temperature

Overall the temperature increases by 4.5ºC (standard deviation: 0.56ºC) compared with the period 1961-1990. The temperature increases most in winter and autumn seasons in the north of Sweden, >5ºC as seen in Figure 1. The SMHI models shows the same pattern but with a slightly larger increase. The maximum daily average temperature, the hottest day each year, increases by ~5ºC (Figure 2), more than the average increase.

3.2 Precipitation

The precipitation increases on average by 20% (SD: 10%) in total. The seasonal and spatial distribution of this increase shows the highest increase of ~40% in north Sweden during winter and spring (Figure 1). There is also a slight decrease <10% in southwest Sweden during the summer months. In all, the d4PDF change in precipitation is very similar to the models used by the SMHI. Finally, the return period analyses show that especially the rare short intense precipitation events increase a lot. The yearly maximum 24hr rainfall increases as much as ~50-75% for rare events as seen in Figure 3.

4. Conclusions

So far not all the d4PDF data has been analyzed and the results must be regarded as preliminary. The JMA/MRI-AGCM model and the d4PDF gives a similar climate as measurements and models from the SMHI. The temperature in Sweden is bound to increase more than the global average and especially so in the northern parts during winter and autumn. The precipitation increases on average 20%, but rare short intense events can increase even more – 50-75%. The highest increase in precipitation occurs in the north during winter and spring. Also, when comparing the future trend to the SMHI models the d4PDF is omitting the trend and uses a different time period. This is a problem when comparing the climate but an advantage for the extreme weather analysis.

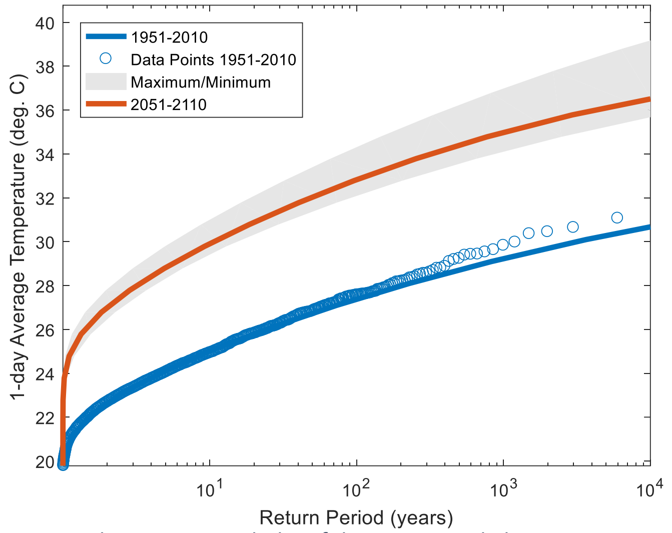

Figure 2: The return period-plot of the maximum daily temperature in all of Sweden. Shaded area indicates the maximum/minimum model average.

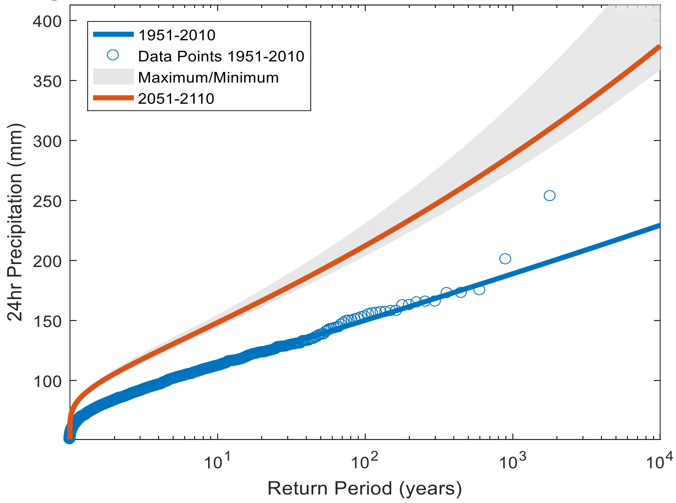

Figure 3: The return period-plot of maximum 24hr rainfall in all of Sweden. The shaded area shows the max/min model average.

References

1) IPCC. (2014). Climate Change 2014: Synthesis Report. http://www.ipcc.ch/pdf/assessment-report/ar5/syr/SYR_AR5_FINAL_full_wcover.pdf

2) JAMSTEC. Experimental design of d4PDF. http://www.miroc-gcm.jp/~pub/d4PDF/design_en.html

3) SMHI. About the analysis: About ensembles. https://www.smhi.se/klimat/framtidens-klimat/klimatscenarier/haag_en.html#omens