Extreme Value Statistics of Downscaled Climate Projections for Turkey and Its Region

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Introduction

Information about climate extremes of the future should constituted essential ingredient for any realistic impact study. This study attempts to extract such information from dynamically downscaled climate projections for Turkey and its region.

In this study, results from several AR4 global climate models (ECHAM5, CCSM and HadCM3) that has been used to force at the boundaries a regional climate model (RegCM3) to obtain dynamically downscaled climate fields at a resolution of 27 km for the historical (1961-1990) reference period and the 21st Century (2011-2099), are used.

Aim of the study is to estimate Generalized Extreme Value (GEV) distribution parameters (location, shape and scale) by using a maximum likelihood approach under the assumption of stationary for each model grid cell and for a number of climate variables (daily maximum temperature, daily minimum temperature, daily total precipitation).

Data

Data format is NetCDF.

Two dataset groups were used. They consist of **daily** Tmax, Tmin and total precipitation.

- For 20th Century (1961-1990)
  - NNRP (NCEP/NCAR Reanalysis Project)
  - ECHAM5 run
- For 21st Century (2011-2040) – A2 scenario of ECHAM5

From these data **seasonal** minimum and maximum temperatures are chosen. We use all daily total precipitation values grouped in seasons.

Theory and Methods

Extreme Value Theory (EVT) is a branch of statistics dealing with the extreme deviations from the median of probability distributions. There are three distribution types of EVT; Gumbel, Fréchet and Weibull. Here, generalized extreme value (GEV) distribution is used.

$$G(z) = \exp\left\{-\left[1+\xi\left(\frac{z-\mu}{\sigma}\right)\right]_{+}^{-1/\xi}\right\}$$

where $y_{+}=max\{y,0\}$, $-\infty<\mu,\xi<\infty$ and $\sigma>0$.

GEV parameters: location μ, scale σ and shape ξ.

CDO (Climate Data Operators) and NCO (netCDF Operators) tools were used for management and filtering of climate variables.

For GEV statistics, R 2.14.1 version, *extRemes* package, *gev.fit and return.level* functions were used.

For the visualization of preliminary findings, NCL (NCAR Command Language) were used.

Results

1961-1990 Maximum Summer Temperatures NNRP vs. ECHAM5

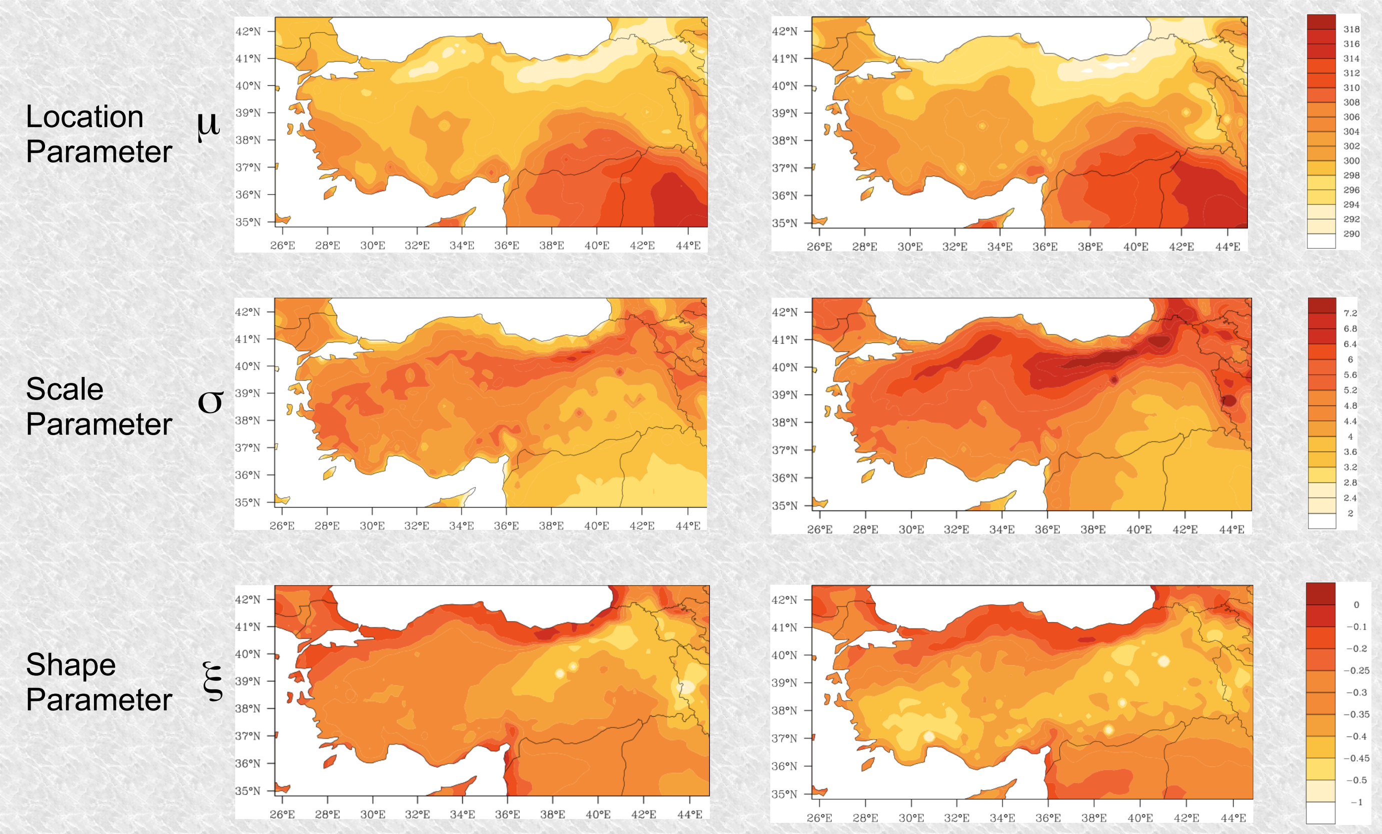
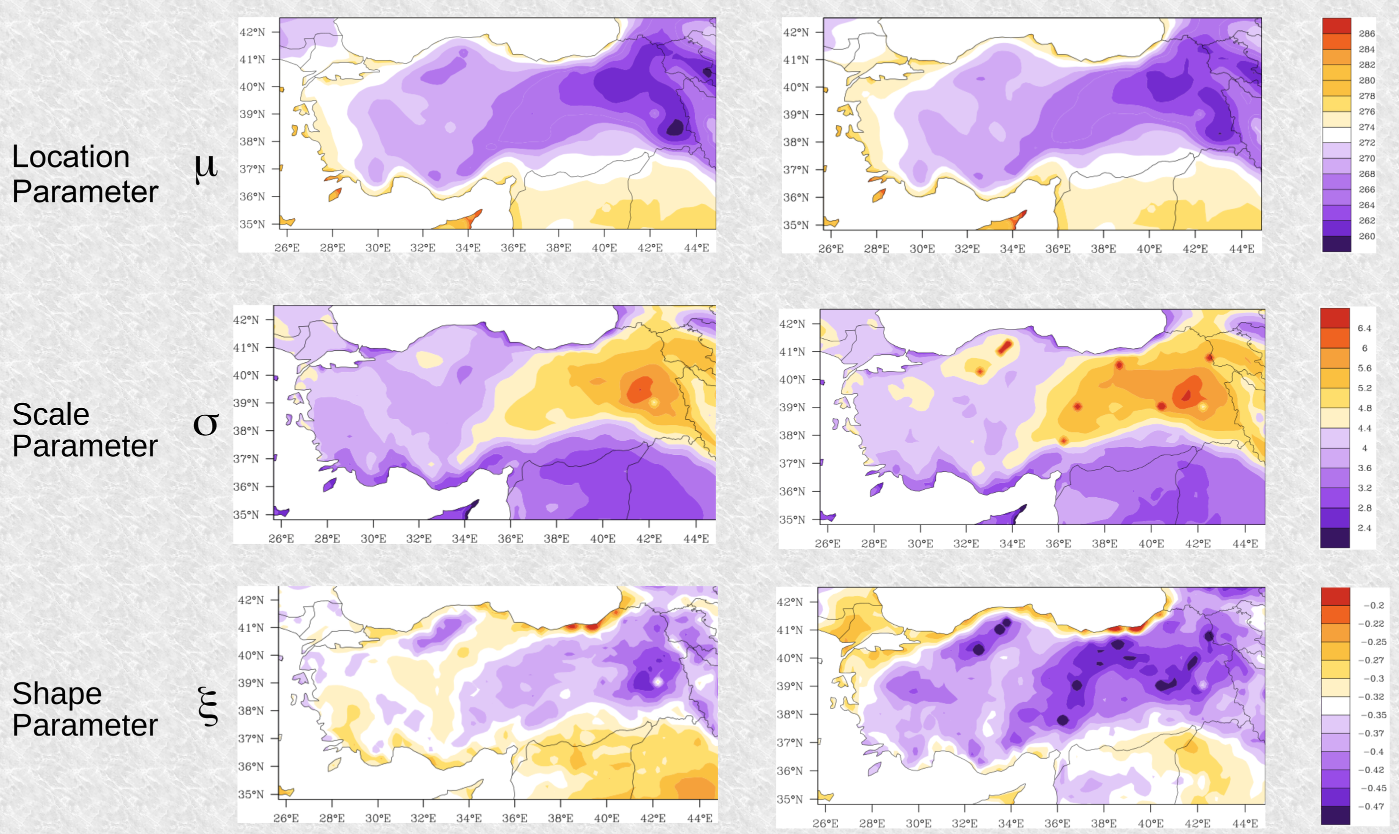


Figure 1-2: Comparison of GEV parameter estimates for 1961-1990 reference period of NNRP and ECHAM5 climate variables. GEV parameters of maximum summer temperatures (above) and minimum winter temperatures (below).

1961-1990 Minimum Winter Temperatures NNRP vs. ECHAM5



2041-2050 Comparison of Models

Model	nllh	μ_0	μ_1	σ_0	σ_1	ξ
0	2578.16	310.52		4.40		-0.41
1	2572.89	309.96	0.0013	4.39		-0.43
2	2599.63	311.76	-0.0014	1.41	0.0002	-0.45

Max. Temperatures - Diyarbakır (Lat: 38.00172, Lon: 40.13868)

Model	nllh	μ_0	μ_1	σ_0	σ_1	ξ
0	2701.02	264.24		5.53		-0.50
1	2700.94	264.35	-0.0002	5.54		-0.51
2	2939.53	268.59	-0.0080	1.96	0.0007	-1.04

Min. Temperatures - Kars (Lat: 40.50070, Lon: 43.03646)

Table 1: Comparison of parameter estimates and nllh (negative log likelihood) of stationary (Model 0) and nonstationary (Model 1,2) GEV fits in midcentury (2041-2050). Model 1 and 2 fit to GEV with a linear trend in the location (μ) parameter, a linear trend in location (μ) and scale (σ) parameters, respectively. According to nllh values, the best model is second model for two different gridboxes.

Return Levels

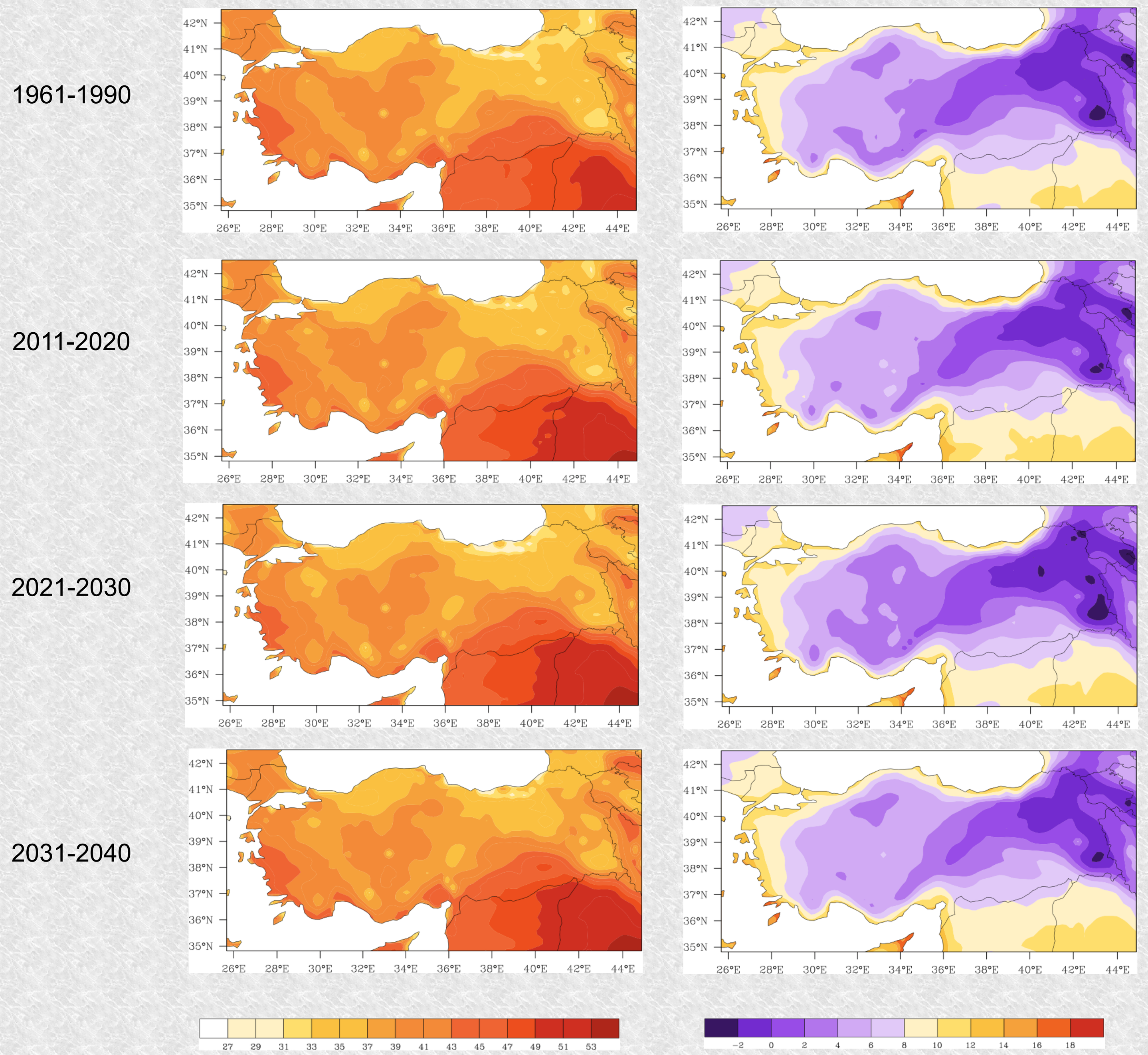


Figure 3: Changes of return levels with 95% confidence interval for 30 years return period of maximum and minimum temperatures.

Comparison of Return Values 1961-1990 vs. 2011-2020

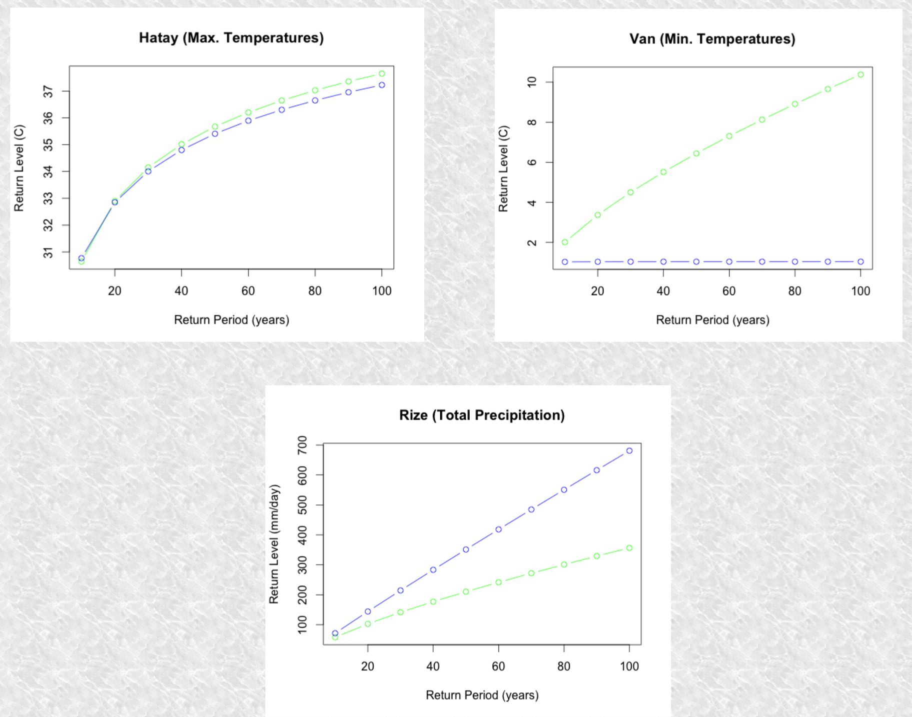


Figure 4: Comparison of return values with 95% confidence interval for 1961-1990 (green) and 2011-2020 (blue) ECHAM5 climate variables in different gridboxes.

Conclusions

- Our preliminary findings indicates NNRP and ECHAM5 forced RegCM3 produces for the reference period comparable GEV parameter values and general patterns, although there are difference in the spatial details.
- Throughout the 21st Century, projected temperature extremes expressed as return values, shifts ranges while preserving general spatial patterns.
- Comparison of stationary and nonstationary GEV fits shows that importance of nonstationarity can not ignored.

References

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