Proposal for transformation of fixed threshold to percentile based climate indices and implication on their change in the future

CC BY

Milica Tosic[1], Vladimir Djurdjevic[2]
University of Belgrade - Faculty of physics, Institute of meteorology
[1]*milica.tosic95@gmail.com*, [2]*vdj@ff.bg.ac.rs*

Introduction

Temperature and precipitation indices are being used to analyze extreme events for various parts of the world. Climate indices can be classified in two main categories:

- indices based on threshold
- indices based on percentile

Systematic errors in climate model results often present a barrier for wider use of climate indices, especially when calculated using the fixed threshold value. We propose and test a method of transformation of fixed threshold indices to percentile threshold indices. This can be one way to overcome a problem of model biases.

Data and method

We identified changes in indices over south-eastern Europe, over the 21st century relative to the reference period 1986–2005, for three future periods:

- near future (2016-2035)
- mid twenty-first century (2046-2065)
- late twenty-first century (2081-2100)

To demonstrate the proposed method over Europe, we chose three fixed threshold indices::

summer days **(SU)**	Number of days with TX > 25ºC
ice days **(ID)**	Number of days with TX < 0ºC
number of days with daily rainfall greater than 10mm **(RR10)**	Number of days with RR ≥ 10mm

Table 1: Threshold-based indices and their definitions.

For this study, indices (their definitions of are taken from *https://www.ecad.eu/indicesextremes/* and are given in table1) were calculated using daily maximum near surface temperature and daily precipitation gridded data extracted from E-OBS and EURO-CORDEX Project database. Outputs are from two regional atmospheric and climate models:

- MPI-CSC-REMO2009
- KNMI-RACMO22E

Considered scenario was RCP8.5.

The initial step in our method is to find corresponding percentile value for each fixed threshold of selected indices, within the historical period 1986-2005, for each grid point of E-OBS data. Then using these percentile values, and model results for the same time period, we set a unique new threshold for each model grid point such that the model-based frequency of events that defines SU, ID, and RR10 is equal to the observed one. Due to the model systematic error (bias) over reference period this new thresholds are different from the fixed values in index definition. Finally, we calculated future changes of the indices, using redefined thresholds and applying them for indices calculation over mentioned future periods.
For this study, it was of interest to verify the proposed method. We compared our results of future changes of the indices with changes obtained from results of the same model which are bias corrected (i.e. bias-adjusted EURO-CORDEX) before calculation of the indices.

Fig.1 illustrates the method applied for one grid point, located 21.24ºE - 42.54ºN. Example is given for index SU and for RCM REMO2009. First, we find the percentile of fixed thresholds for certain index (eg. SU), for historical period 1986-2005, using E – OBS gridded climatology dataset. Based on values of percentile, new value of thresholds was defined for modeled data

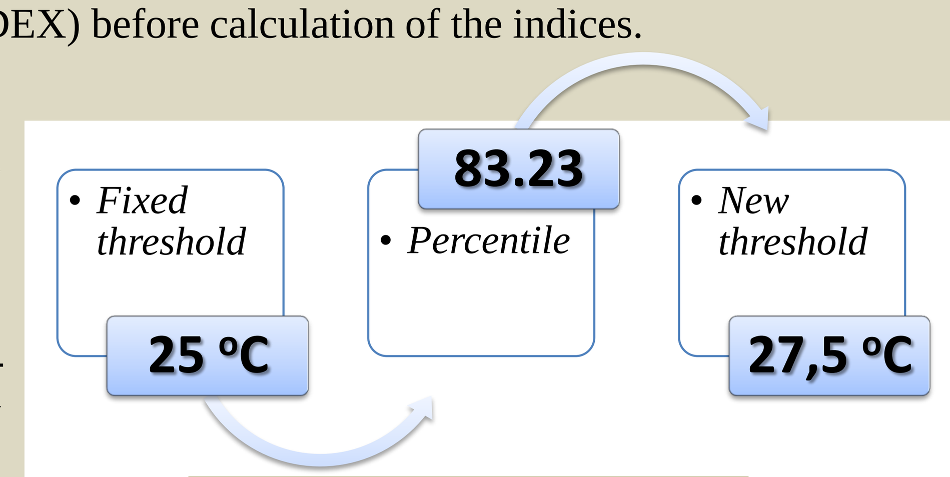

Figure 1: Method illustration

Results

As an example, one temperature index is presented – **SU** and one model – **REMO2009**. Results are shown in Figures 2, 3. and 4 Fig. 2 a) represents index calculated using observed data, (average values for period 1986-2005). Fig. 2 also depicts model bias - how indices obtained with RCM data, differ from indices computed using observational dataset (“MODEL – EOBS’’), for certain model (fig. 2 b)) and same model when bias-adjusted (fig. 2 c)). The results of this analysis for future periods are then compared with the calculation of indices for bias-adjusted model. Future change of indices is represented through variable Δ:

$$\Delta = I_{2081\text{-}2100} - I_{1986\text{-}2005}$$

where *I* is the value of certain index, model and period. For this purpose we used 1986-2005 (historical) and 2081-2100 time periods to represent changes. It is shown in Fig. 3 a) how do indices based on original threshold change in future, for bias-adjusted RCM REMO2009 (Δ_{adj}) . We then analyze how future changes of fixed-threshold (Δ_{fix}) and new, percentile based, threshold (Δ_{pct}) indices differ from Δ_{adj} field, which is depicted in fig. 3 b) and c), respectively.

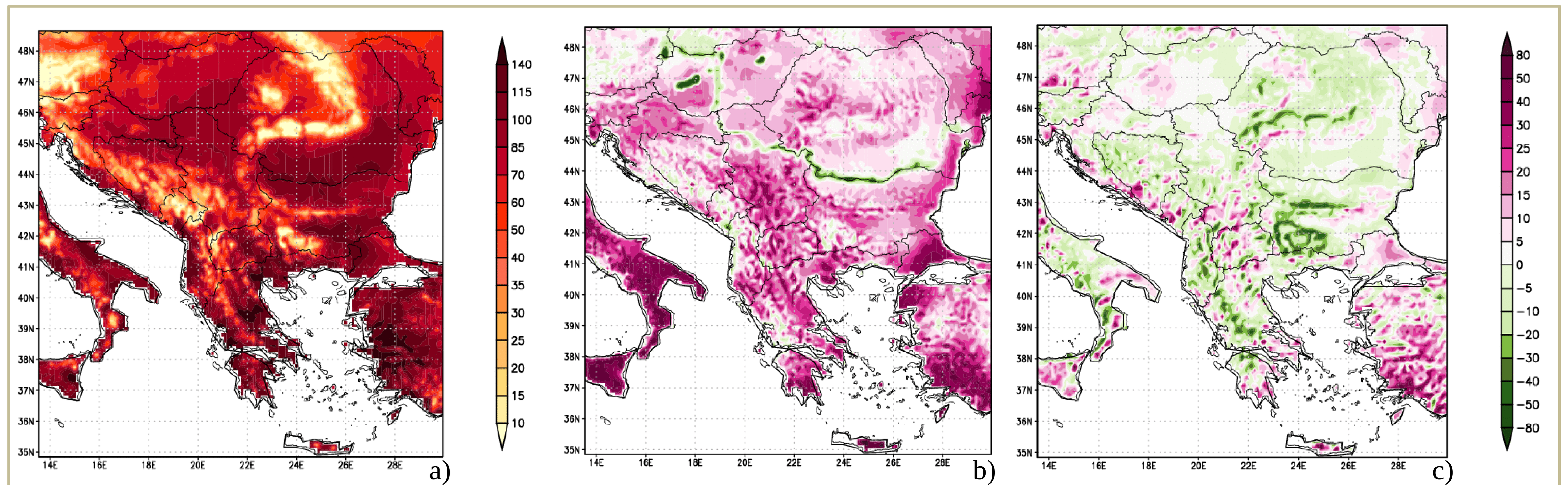

Figure 2 – SU index values for historical period: E-OBS data (a); model bias for REMO2009 (b) and bias adjusted REMO2009 (c).

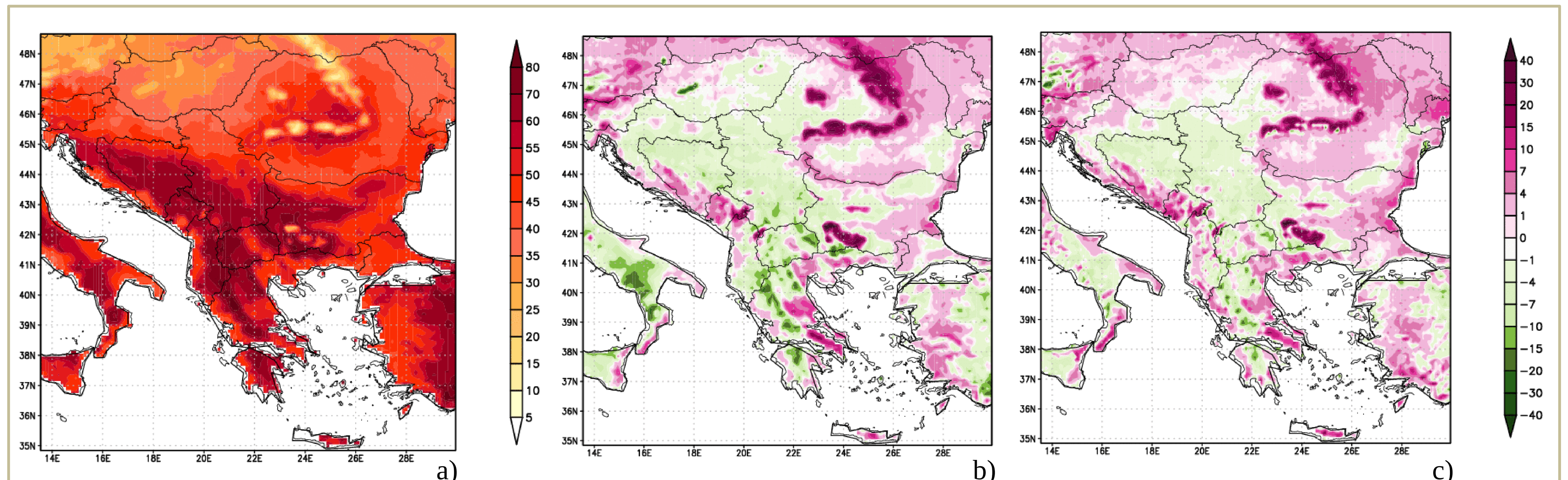

Figure 3 – Future changes of SU REMO2009 bias-adjusted, Δ_{adj} (a); deviation of Δ_{fix} (b) and Δ_{pct} (c) from Δ_{adj}

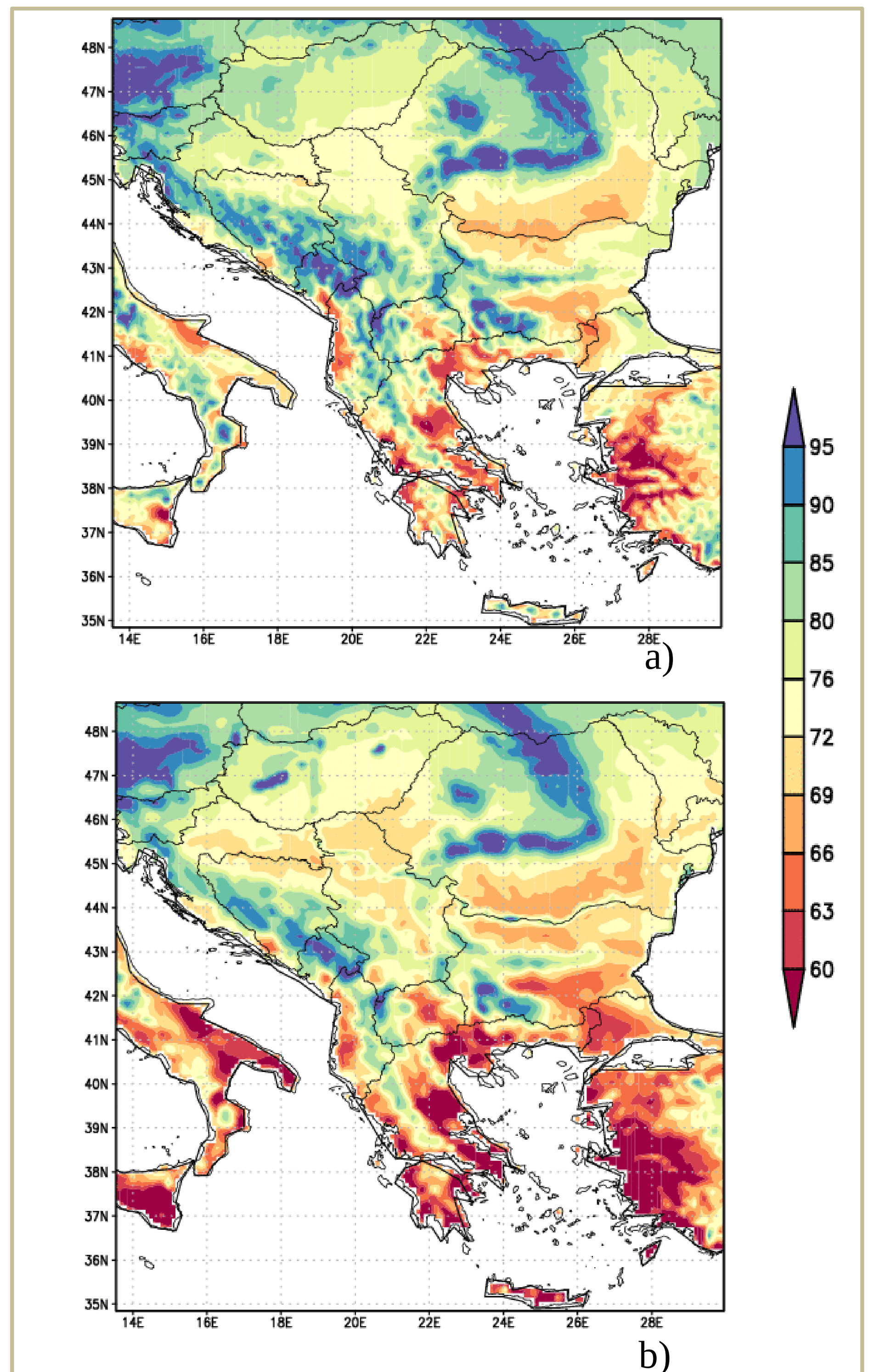

Figure 4 – Percentile values of TX=25 ºC, in E-OBS (a) and REMO2009 (b) daily maximum temperature dataset, for 1986-2005.

Conclusions

Conclusions are similar for both RCM. According to results for the RCP8.5 scenario, each model decreases in frequency of cold events and increases in warm events can be expected. Changes in precipitation indices exhibit much complex pattern. Redefining extreme events in the way of illustrated method leads to elimination of model bias for event frequency in the historical period (1985-2005). On the other hand, difference between two thresholds, the fixed one and the one for the model data, that is shifted, can be seen as an estimate of systematic bias in model results. Comparison of our results of indices' future changes with indices changes obtained from bias adjusted model indicate validity of the proposed method.

Different methods of bias-correction aim to improve the quality and accuracy of RCM's output data. Considering that bias-adjusted data are available just for limited number of all models in EURO-CORDEX ensemble, we believe this method will aid researchers by increasing number of ensemble members that could be used for analysis of future changes of climate indices, without bias correction of temperature and precipitation.