The evaluation of vulnerability to extreme climate events over Balkan Peninsula using modified Climate Extremes Index

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Introduction

Assessing the variability of climate extremes in changing climate is one of the greatest and most important challenges in climate science, not only because these events are rare, but also because they can be accompanied by devastating consequences. Climate change in the future could lead to an increase in the frequency, intensity and duration of extreme events and the greatest impact on the global ecosystem will be manifested through extreme weather events.

The aim of this study is to estimate exposure to the aggregated climate extremes in historical and future climate. In order to explain the combined impacts we decided to use the modified Climate Extremes Index (mCEI) developed by Kelebek et al. [1].

Data and method

The domain of our study is focused on the Balkan peninsula, because this area is marked as one of the major hotspots for the combined extremes. For the calculation of the annual and seasonal values of mCEI we first calculated ten different percentile based climate indices:

Tmax
Tmin
scPDSI
Prec.
Prec. (no. of days)

> 90th percentile

< 10th percentile

Each of the percentile values is calculated using the 1961–1990 standard reference period. We used E – OBS observational gridded dataset with horizontal resolution 0.1 degree, for historical period (1951 – 2020). For the annual and seasonal (DJF, MAM, JJA,SON) time series, the trend of the index was computed and tested for statistical significance using the nonparametric Man-Kendall test and the Sen's slope estimator.

For future projections we used data extracted from EURO-CORDEX Project database. Considered scenario was RCP8.5.

We analyzed changes in indices in Serbia, over the 21st century relative to the reference period 1971–2000, for three future periods:

- near future (2011-2040)
- mid twenty-first century (2041-2070)
- late twenty-first century (2071-2100)

The individual change of each index integrated in mCEI was analysed to better understand the drivers of the final mCEI.

References

[1] Kelebek, M.B., Batibeniz, F. and Önol, B., 2021. Exposure assessment of climate extremes over the Europe–mediterranean region. Atmosphere, 12(5), p.633.

Results

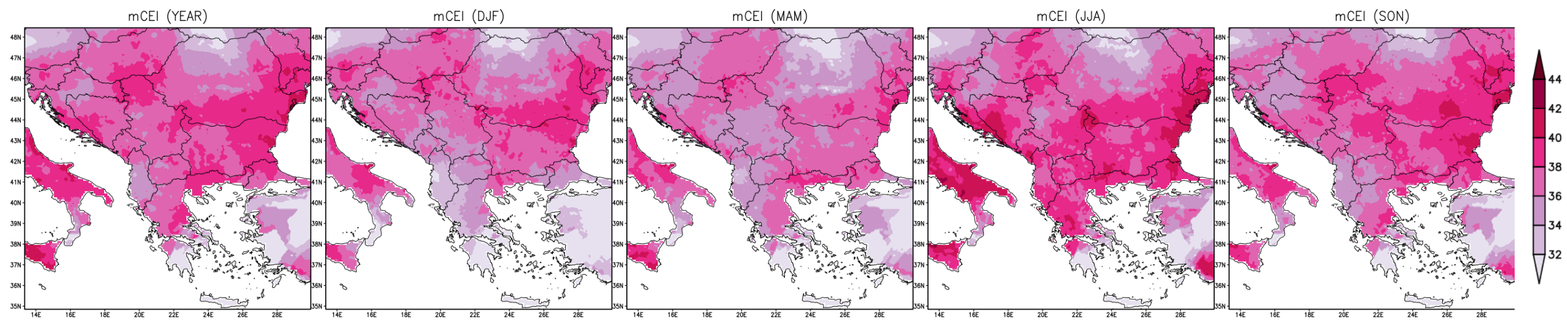

Figure 1: The spatial pattern of index mCEI in annual (YEAR), winter (DJF), spring (MAM), summer (JJA), and autumn (SON) time scales during 1951–2020.

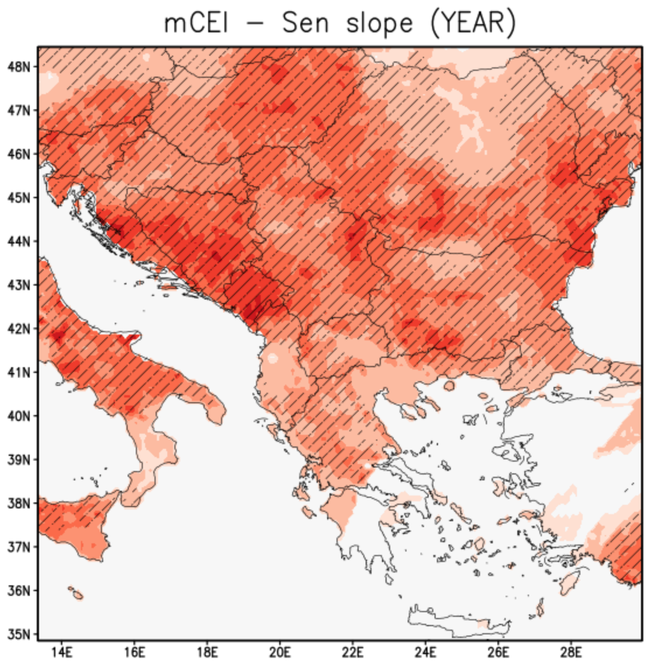

Figure 2: The spatial pattern of trends in mCEI in annual (YEAR time scales during 1951–2020. Significant ($p \leq 0.05$) trends are crosshatched.

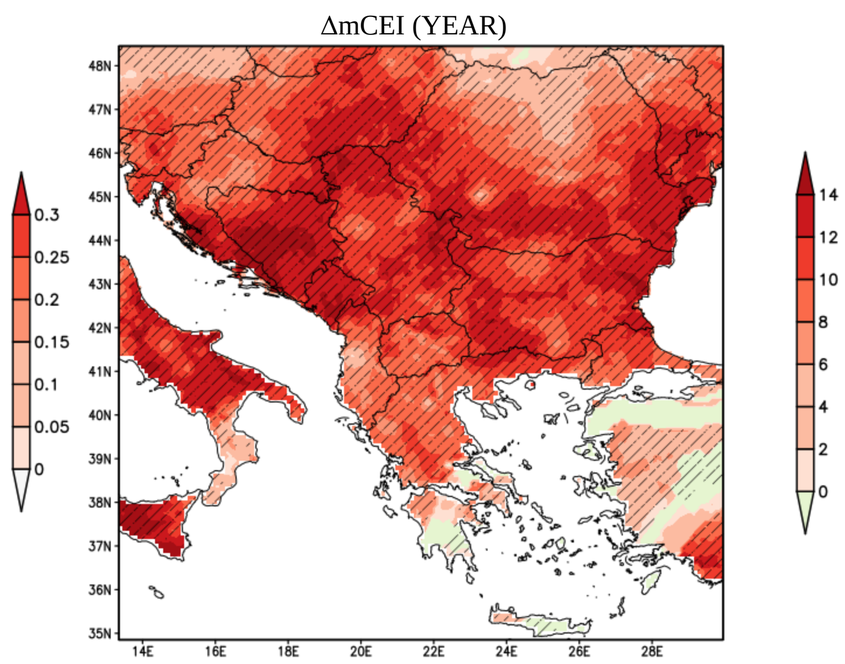

Figure 3: Spatial distribution of changes in mCEI in annual (YEAR) time scales from1961–1990 to 1991–2020. Significant ($p \leq 0.05$) change is crosshatched.

The spatial distribution of the mCEI averaged over the period of 1951–2020 for all seasons and on the annual basis is presented in Figure 1. The greatest values are in JJA, because of the influence of warm extremes during summer. The spatial pattern of trends in mCEI in Balkan peninsula during the period of 1951–2020 is shown in Figure 2 which mainly shows a significant increasing trend (at the 5% level of significance) of 0.05 to 0.4 % per year in all seasons and on an annual basis. There is an increase in means of mCEI between two standard periods (1961–1990 and 1991–2020) and the *t*-test was applied to check the stability of that change (ΔmCEI , Figure 3).

Then, we focused on the territory of Serbia and calculated future changes of the indices. Figure 4 shows mean values from selected models ensemble of changes in mCEI (on the annual basis) for three future periods. According to RCP8.5, we can expect an increase greater than 15% in aggregated climate extremes by the end of the century.

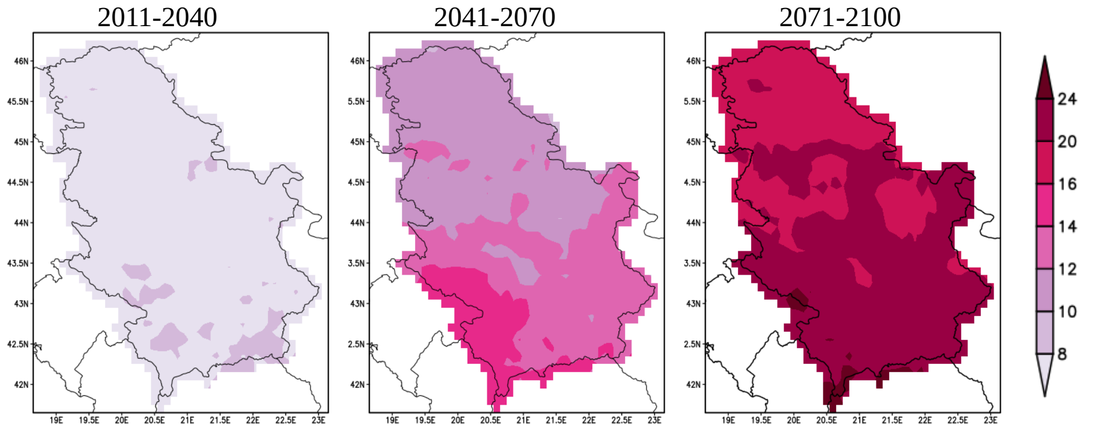

Figure 4: Change in ensemble mean of anomaly of mCEI index for the periods with respect to mean value for the period 1971-2000.

Conclusions

Results showed that a warming trend dominated for the last seventy years. The analysis of mean and extreme temperature indices shows a general tendency for a significant increase in the following temperature indices: We conclude that mCEI is a very useful tool because it assimilates the effects of different extreme climate conditions in one combined index. We found that our research area has experienced an increase in extremes in recent decades and, according to scenario RCP8.5 for climate projections, an upcoming change that exposure to these extremes is expected to exceed in the future and become more vulnerable to climate extremes.