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Projections of changes in the occurrence of dry periods and extreme precipitation in the Czech Republic in the future

(Odhady změny ve výskytu období beze srážek a extrémních srážek na území ČR v budoucnosti)

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Abstract: As part of our assessment of climate change related risks, this paper focuses on projections of changes in the occurrence of dry periods and extreme precipitation in the Czech Republic for the period 2021–2100. To estimate these changes, indices based on daily precipitation totals have been used. The data of ALADIN-CLIMATE/CZ model simulation for the SSP2-4.5 and SSP5-8.5 emission scenarios were used. Future changes in the occurrence of dry periods were studied based on evaluation of the maximum length of periods of consecutive dry days with total rainfall below 2 mm. To assess changes in the frequency of extreme precipitation totals, the number of days with a precipitation total reaching at least the 99th percentile of daily precipitation totals for the historical period 1995–2014 was calculated. The changes in the maximum length of consecutive dry days with total rainfall below 2 mm are unequal on the territory of the Czech Republic. Longer periods of consecutive dry days with total rainfall below 2 mm can be expected under both emission scenarios in the Ore Mountains Foreland, and at the end of the century also in western Bohemia and southern Moravia, shorter in the higher-altitude regions of the Czech Republic except for the Šumava Mountains. Conversely, an increase in extreme precipitation in the future can be expected in northeastern Moravia under both emission scenarios for all periods studied, and in Bohemia under the SSP5-8.5 emission scenario during the periods 2061–2080 and 2081–2100.

Keywords: dry days – extreme precipitation

Abstrakt: V rámci hodnocení rizik spojených se změnou klimatu jsme se v příspěvku zaměřili na projekci změn ve výskytu období sucha a extrémních srážek na území České republiky v období 2021–2100. Pro odhad změn jsme využili indexy založené na denním úhrnu srážek. Jako vstupní data byly využity výstupy modelu ALADIN-CLIMATE/CZ pro emisní scénáře SSP2-4.5 a SSP5-8.5. Budoucí změny ve výskytu suchých období byly studovány na základě maximální délky souvislého intervalu s denními úhrny srážek do 2 mm. Pro hodnocení změn v četnosti extrémních úhrnů srážek byl zpracován počet dní s úhrnem srážek dosahujícím alespoň hodnoty 99. percentilu denního úhrnu srážek pro historické období 1995–2014. Očekávané změny maximální délky souvislého období s denním úhrnem srážek do 2 mm v budoucnosti nejsou pro území České republiky rovnoměrné. Delší bezesrážková období lze očekávat dle obou emisních scénářů v Podkrušnohoří, ke konci století také v západních Čechách a na jižní Moravě, kratší ve vyšších nadmořských výškách kromě Šumavy. Naopak nárůst extrémních srážek v budoucnosti lze očekávat dle obou uvedených emisních scénářů na severovýchodní Moravě pro celé období 2021–2100, dle emisního scénáře SSP5-8.5 v období 2061–2080 a 2081–2100 i v Čechách.

Klíčová slova: období sucha – extrémní srážky

Introduction

To develop appropriate adaptation strategies and tools for managing the climate change related risks, it is important to understand projected trends in extreme weather events that pose a risk to society and the environment. In the European Environment Agency report (European Climate Risk Assessment 2024) 36 climate risks with potentially severe consequences across Europa were identified. For the territory of the Czech Republic, we consider the following risks to be relevant: those associated with the occurrence of extreme air temperatures and changes in average air temperature, changes in precipitation patterns and the occurrence of extreme precipitation, drought, and weather conducive to wildfires, changes in airflow and the occurrence of extreme winds, and changes in snow cover.

In this paper, we will focus on assessing changes in the occurrence of dry periods with total rainfall below 2 mm and extreme precipitation in the future.

Data

For evaluation of the future changes in the occurrence of extreme precipitation the simulation of ALADIN-Climate/CZ regional climate model for the SSP2-4.5 and SSP5-8.5 emission scenarios for the period 2021–2100 and the historical model run (1995–2014) was used. ALADIN-Climate/CZ model driven by the CNRM-ESM2-1global climate model with horizontal resolution of 2.3 km covers extended Central Europe (Brožková et al. 2019). The occurrence of dry periods and extreme precipitation was studied based on bias-corrected daily precipitation totals for the territory of the Czech Republic.

Method

To assess changes in the character of dry periods, the maximum length of consecutive dry days with total rainfall below 2 mm was calculated (Karl et al. 1999; Peterson et al. 2001). The threshold 2 mm is different of commonly accepted limit 1 mm, but it was chosen with regard to previous climate changes studies for the territory of the Czech Republic (Pretel et al. 2011) and technical practice. For each grid cell, the maximum length of a dry spell was calculated for the historical model run (1995–2014) and the individual 20-year periods 2021–2040, 2041–2060, 2061–2080, and 2081–2100. The development was studied based on the difference in the maximum length of the dry period for a given twenty-year period and the historical model run.

To study changes in the frequency of extreme precipitation totals, the number of days with a precipitation total reaching at least the 99th percentile of daily precipitation totals for the historical period 1995–2014 was calculated for the above-mentioned twenty-year periods for each grid cell (Anagnostopoulou, Tolika 2011). To determine the 99th percentile of daily precipitation totals, all days, i.e. wet and dry days were included in the calculation. This approach is recommended, for example, in (Riccetti et al. 2025; Schär et al. 2016).

The kriging method was used to interpolate the maps of both indices. On the maps showing the number of days with daily precipitation totals that reached at least the 99th percentile of daily precipitation totals for the period 1995–2014, areas where the 99th percentile of daily precipitation was reached or exceeded in less than 1% of cases are marked with the same colour; i.e. the 99th percentile for these areas during the given 20year period is lower than the results of the historical run of the ALADIN-CLIMATE/CZ model.

Results

Dry periods

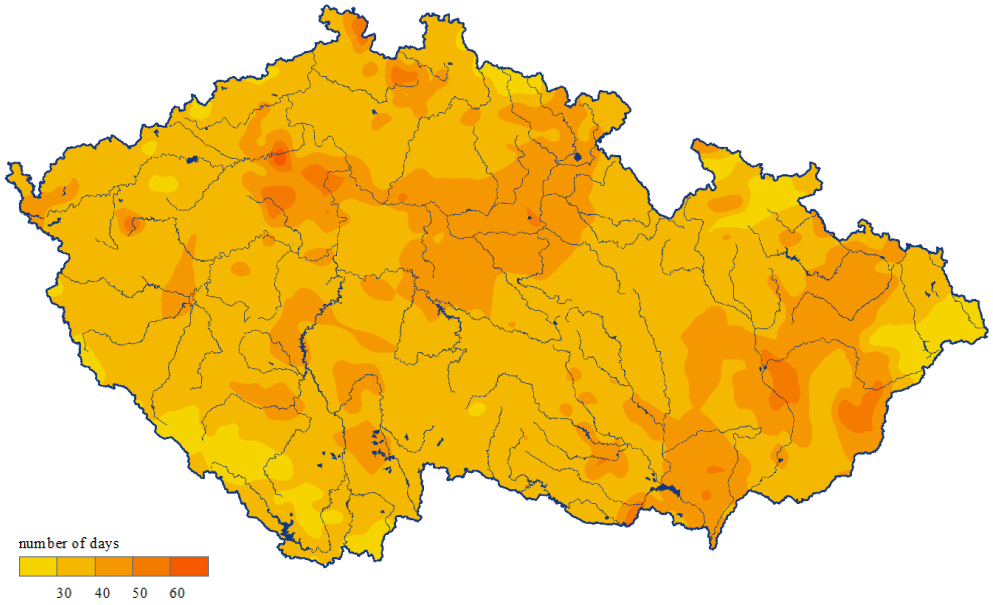


Fig. 1. The maximum length of consecutive dry days with total rainfall below 2 mm determined based on the output of the historical run of the ALADIN-Climate/CZ model for the period 1995–2014.

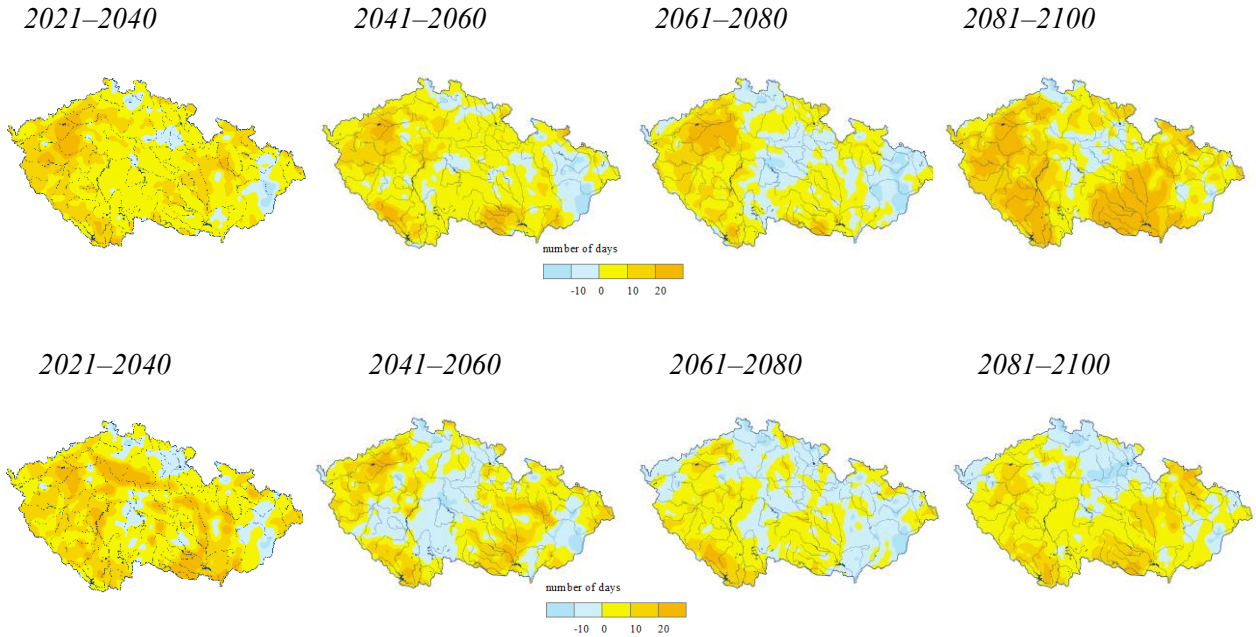


Fig. 2. Changes in the maximum length of consecutive dry days with total rainfall below 2 mm in the future, based on ALADIN-Climate/CZ data for the SSP2-4.5 emissions scenario (above) and for the SSP5-8.5 emissions scenario (below) for the periods 2021–2040, 2041–2060, 2061–2080, and 2081–2100.

Daily precipitation

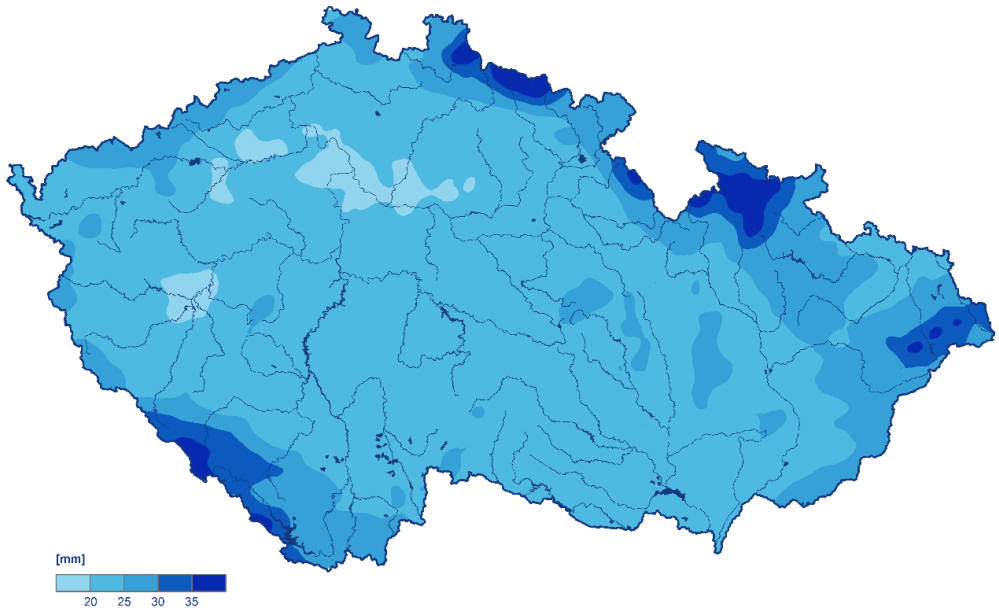


Fig. 3. The 99th percentile of daily precipitation totals determined based on the results of the historical run of the ALADIN-Climate/CZ model for the period 1995–2014.

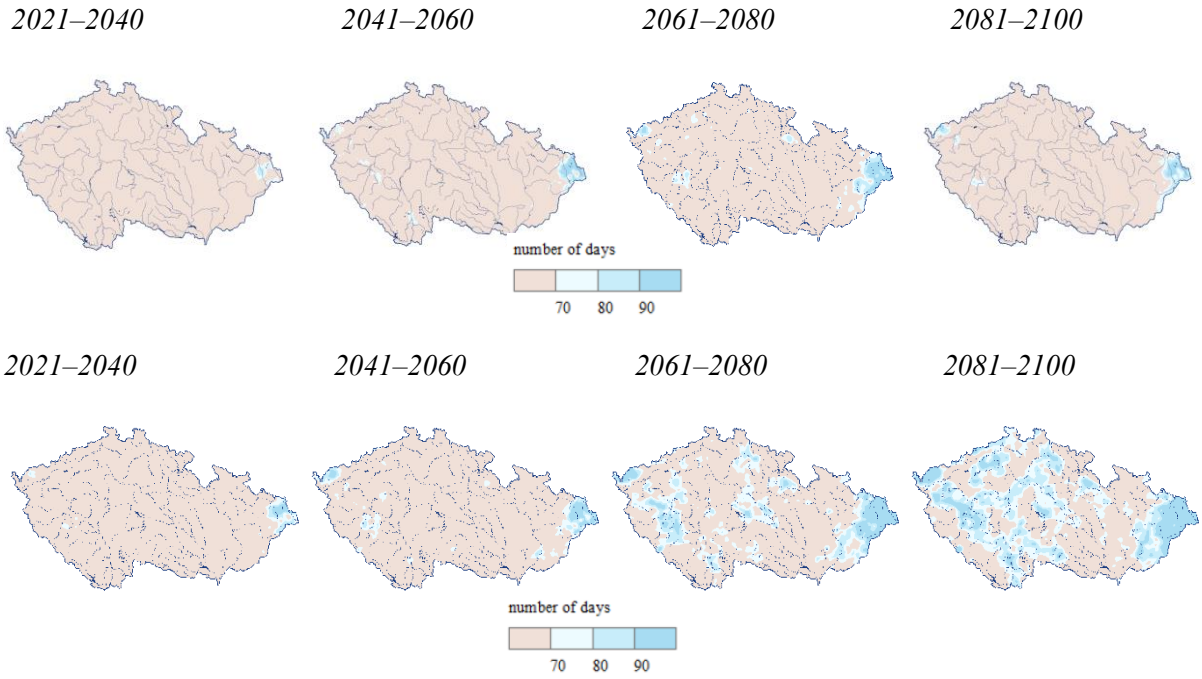


Fig. 4. Number of days with daily precipitation totals reaching at least the 99th percentile of daily precipitation totals for the 1995–2014 period, based on ALADIN-Climate/CZ data for the SSP2-4.5 emissions scenario (above) and for the SSP5-8.5 emissions scenario (below) for the periods 2021–2040, 2041–2060, 2061–2080 and 2081–2100.

Discussion

The maximum length of consecutive dry days with total rainfall below 2 mm (Fig. 1) on the territory of the Czech Republic for the historical run 1995–2014 is between 20 to 69 days, on the most of the territory is between 30 to 40 days. Expected future changes are not uniform over time and space. For both scenarios, increase can be expected in the period 2021–2040 in particular in the Ore Mountains Foreland, and in the period 2081–2100 under scenario SSP2-4.5 also in western Bohemia and southern Moravia. Shorter or comparable maximum length of consecutive dry days with total rainfall below 2 mm is expected for both emission scenarios in the higher-altitude regions of the Czech Republic except for the Šumava Mountains for the periods 2041–2060 and 2081–2100 for the scenario SSP5-8.5 and for both scenarios for the periods 2061–2080 and 2081–2100 in the Elbe lowlands and in the part of southern Moravia (Fig. 2).

The value of 99th percentile of daily precipitation for the historical run of the ALADIN-CLIMATE/CZ model for the period 1995–2014 on the territory of the Czech Republic is between 18.6 to 46.9 mm, on the biggest part of territory is between 20 and 25 mm (Fig. 3). Higher number of days with extreme precipitation can be expected in northeastern Moravia under both emission scenarios for all periods studied, and in Bohemia under the SSP5-8.5 emission scenario during the periods 2061–2080 and 2081–2100 (Fig. 4).

Conclusion

Based on an assessment of changes in the maximum duration of consecutive days with total rainfall below 2 mm across the Czech Republic, both longer and shorter dry periods can be expected depending on the region in the future. According to both scenarios, the longest rainless periods are expected in Ore Mountains Foreland region. Conversely, an increase in extreme precipitation in the future is expected under both scenarios in northeastern Moravia, and – according to the SSP5-8.5 emissions scenario – in Bohemia during the periods 2061–2080 and 2081–2100.

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