Supplementary Material 1. Territorial air temperatures and precipitation sums in the Czech Republic 1961-2020 [1]

Matějka K., Modlinger R.: Climate, *Picea abies* stand state, and *Ips typographus* in the Czech Republic from a viewpoint of long-term dynamics

Based on the measured temperatures between 1961 and 1990, so-called temperature normals were published (KVĚTOŇ 2001). The development of a number of weather characteristics between 1961 and 1998 was evaluated in HUTH ET POKORNÁ (2004). Since 1998, however, a number of extreme situations have occurred, a number of temperature and precipitation extremes (mainly maximum temperatures) have been overcome. For example, NEKOVÁŘ ET POKORNÝ (2012) dealt with temperature changes within similar periods but within limited regions. Rainfall again for a single region was analysed in the work of DOLEŽELOVÁ (2012). Therefore, it is necessary to carry out further evaluation in order to reveal the latest trends in the entire territory of the Czech Republic. The following graphs provide an overview of the development of "territorial temperatures" (average temperatures on the territory, which are related to the average altitude of this territory) and "territorial precipitation" (similar average totals of precipitation sum on the territory) of the Czech Republic according to reports published by the Czech Hydrometeorological Institute in Prague (CHMI portal: historical data, www.chmi.cz). For example, PRETEL (2012) provides a brief overview of changes in these territorial weather characteristics. The basis of the following analysis was the determination of the trend in data for individual months or for the whole year using linear regression analysis in the period 1961-2020. Based on a visual evaluation of deviations from the established trend, it is possible to assess whether a certain variable changed consistently regularly or if it showed a trend different from the following and previous periods in certain partial periods.

Basic trends

Air temperature

The average annual temperature for the entire monitored period was 7.9 °C. Cold years were concentrated at the begin of the observed period - these were the years 1962, 1980 and 1996 (6.3 °C), 1995 (6.4 °C) and 1963 (6.5 °C). On the contrary, the warmest were the years 2018 (9.6 °C), 2019 (9.5 °C), 2015 and 2014 (9.4 °C) and the three years 2000 - 2007 - 2020 with the same temperature 9.1 °C.

Overall, the average annual temperature increased significantly by 0.0344 °C/year ($P <$ 0.01%). In the winter months from December to February, the average temperature increase was 0.0420 °C/year. In the months of the growing season (May to August), the increase was similar, 0.0411 °C/year. The most temperature-stable period of the year is early autumn – September and October.

Temperatures were stable until 1982, an increase in temperatures is visible since 1983. Since 1995, the average annual increase in temperature has been 0.0602 °C/year. Until 1994, a

[1] This Supplementary material is English version of the web document available at https://infodatasys.cz/climate/KlimaCR1961_2020.htm

significant increase was observed in January and August, but in the following years, the temperature increase was mainly realized in November and December.

A different picture provides a view of the period of intense vegetation growth in the months of May to August (vegetation season, while this period is also defined differently). In this period the average temperature was 15.8 °C and the years with the warmest vegetation season were 2018 (18.5 °C), 2003 (18.4 °C), 1992 (17.7 °C), 2002 (17.6 °C), and 2015 (17.5 °C).

The temperature extreme year 2003, often mentioned especially in ecology (REBETEZ ET AL. 2006), was not exceptionally warm as a whole (with an average of 7.6 °C), but within this year the beginning of summer – May and June (15.1 °C and 15.5 °C respectively).

Precipitation

For the entire monitored period, the average annual precipitation sum was 673 mm. The average annual increase in precipitation totals calculated for the entire period 1961–2020 was only 0.329 mm/year, that rainfalls have no significant trend.

A winter increase in precipitation totals was observed in January. In February and March, we see little to no change in precipitation. Precipitation in March before 1980 was very even. There is a clear decrease in precipitation in April. Such a decrease, but less pronounced, continues in May and June. On the contrary, an increase in totals can be seen in July. August is invariable in terms of precipitation. September and October show an increase in precipitation totals, but differently in the different evaluated periods.

It is necessary to notice the extremely high precipitation totals. Winter extremes were recorded in December 1974 (104 mm, 225% of the 1961-2016 average), January 1976 (104 mm, 246%), and February 1970 (87 mm, 237%). The spring period does not have higher rainfall totals - the extremes were in March 2000 (117 mm, 273%) and in April 1965 (80 mm, 187%). Extreme totals during the growing season followed: May in 1965 (141 mm, 196%) and 2010 (133 mm, 185%), June in 2020 (152 mm, 181%) and 2013 (146 mm, 178%), in July 1997 (204 mm, 240%), in August 2002 (177 mm, 227%), then in September 2007 (117 mm, 214%), in October 1998 (113 mm, 256%). Only insignificant extremes were recorded in November. Overall, the winter extremes (December to February) occurred in the 1970s. Spring–summer (March to August) extremely high precipitation totals have been observed since 1997. The 1980s to the mid-1990s were characterized by even or lower precipitation totals. The occurrence of floods should also be related to extreme precipitations. It is interesting that the frequency of floods on the Vltava and the Elbe was minimal in the 1960s (KYSELÝ ET AL. 2008) and at the same time, the occurrence of extremely high summer precipitation totals is not mentioned above in this period. At the same time, however, flood activity has been increasing since the 1970s, with a maximum at the turn of the 1970s and 1980s. Further attenuation is apparently also related to the function of the constructed dam cascade.

Similar to high precipitation totals, the occurrence of dry periods, which were described in the work of TREML (2011) for the period since 1875, is also essential for the analysis. Although the three driest years occurred towards the end of the observed period (2003 516 mm, 2018 521 mm and 2015 532 mm), but even in the first part of the period from 1961, the occurrence of dry years was more frequent (1982 539 mm, 1973 542 mm, 1969 567 mm).

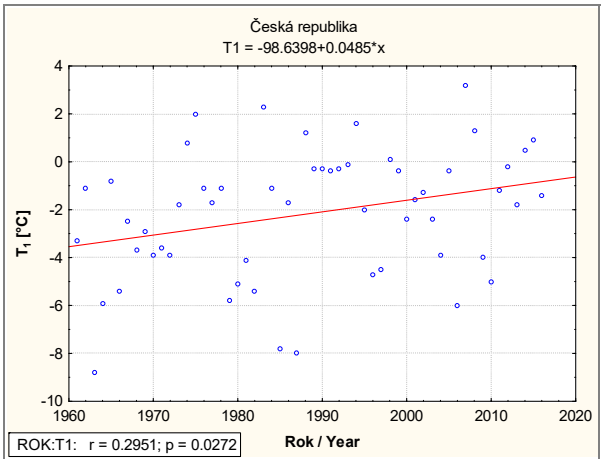

Figure S1-1. Territorial air temperatures in January

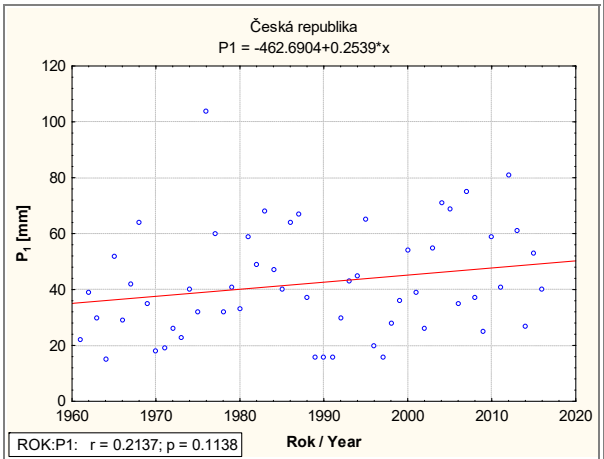

Figure S1-2. Territorial precipitation sums in January

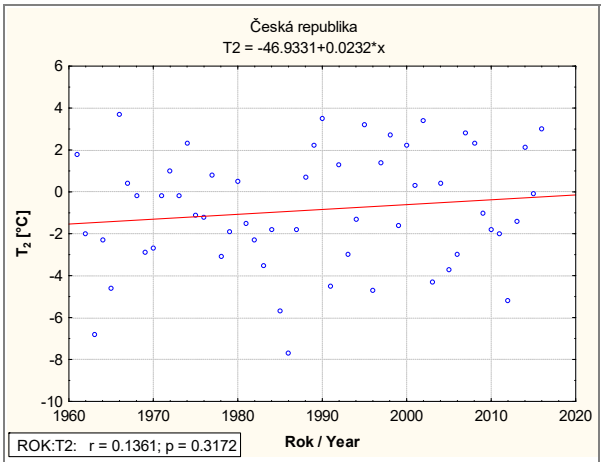

Figure S1-3. Territorial air temperatures in February

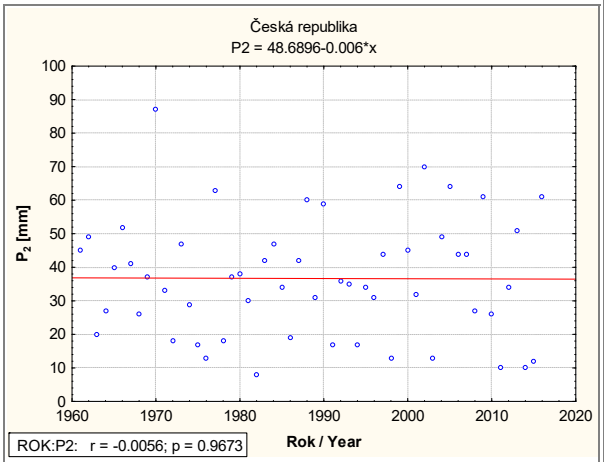

Figure S1-4. Territorial precipitation sums in February

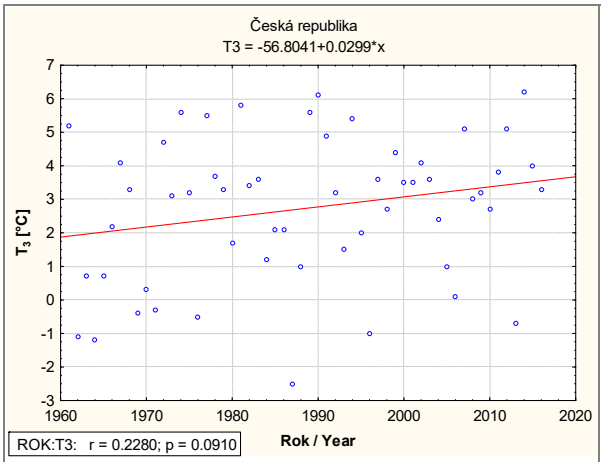

Figure S1-5. Territorial air temperatures in March

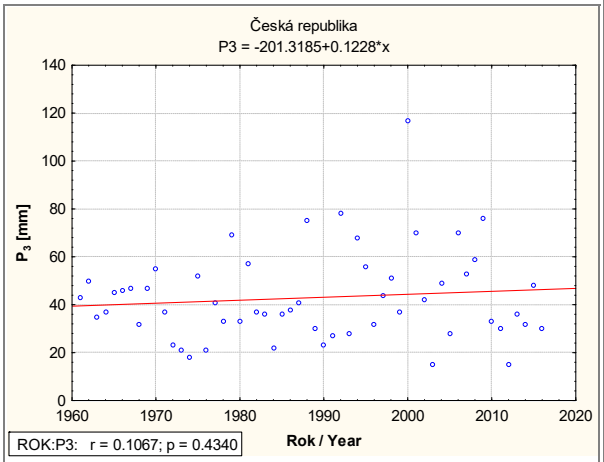

Figure S1-6. Territorial precipitation sums in March

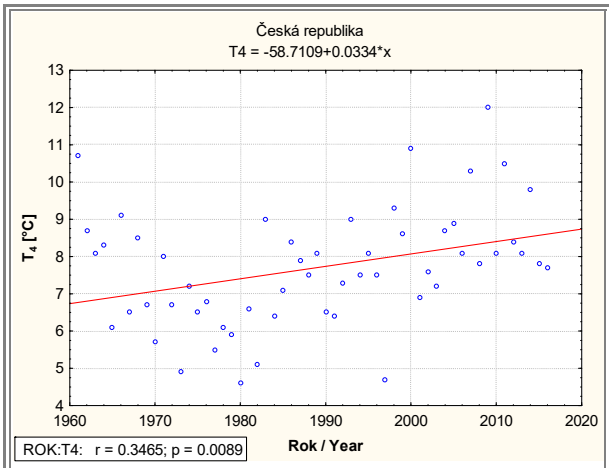

Figure S1-7. Territorial air temperatures in April

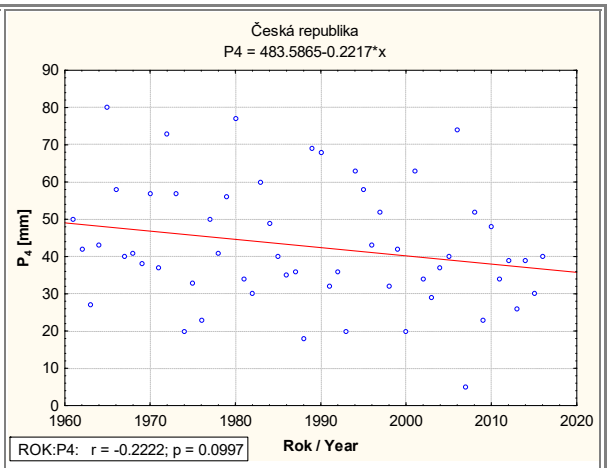

Figure S1-8. Territorial precipitation sums in April

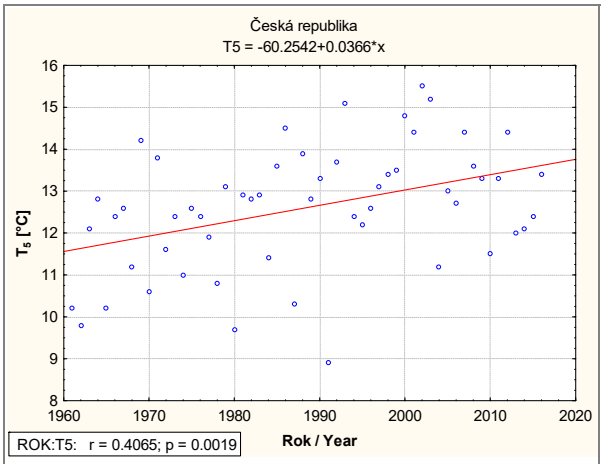

Figure S1-9. Territorial air temperatures in May

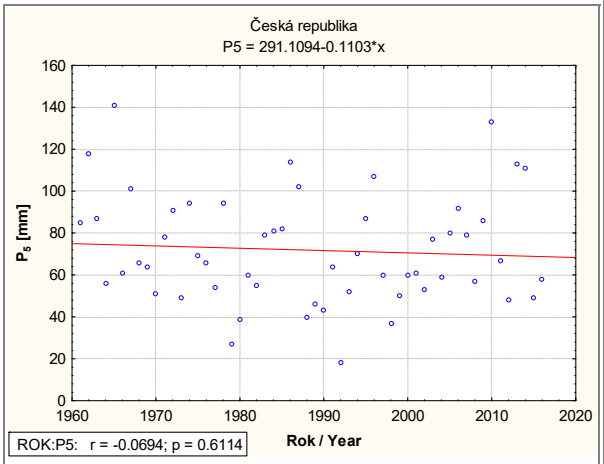

Figure S1-10. Territorial precipitation sums in May

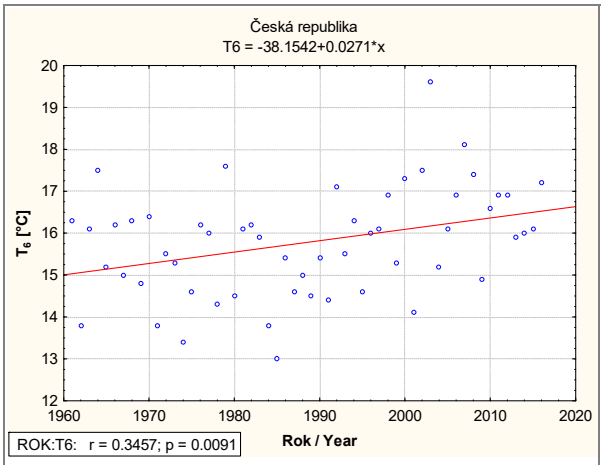

Figure S1-11. Territorial air temperatures in June

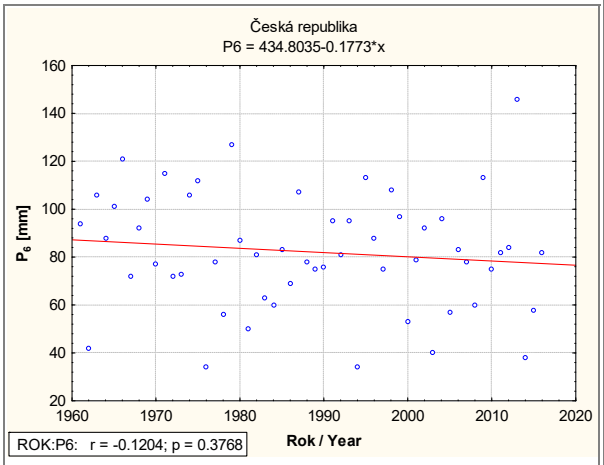

Figure S1-12. Territorial precipitation sums in June

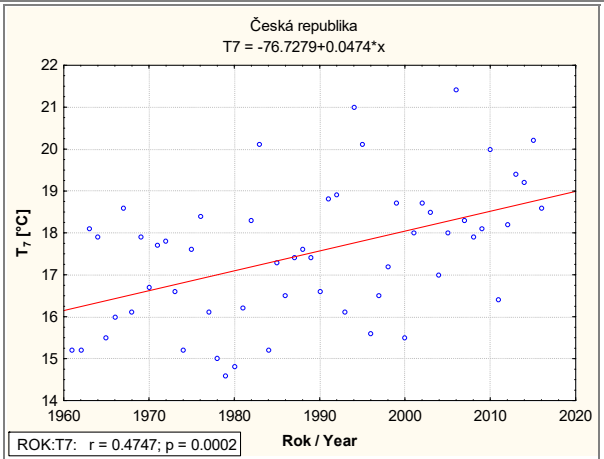

Figure S1-13. Territorial air temperatures in July

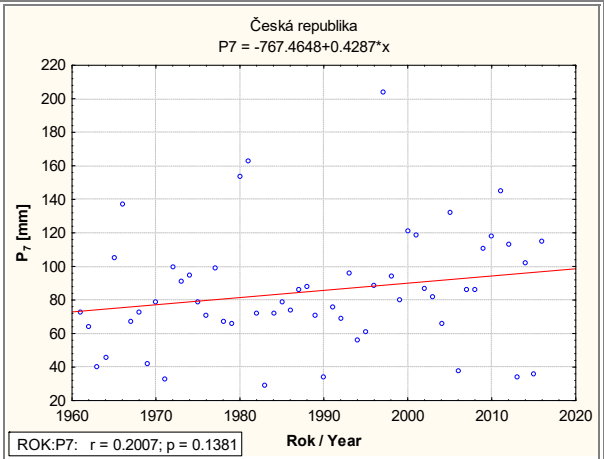

Figure S1-14. Territorial precipitation sums in July

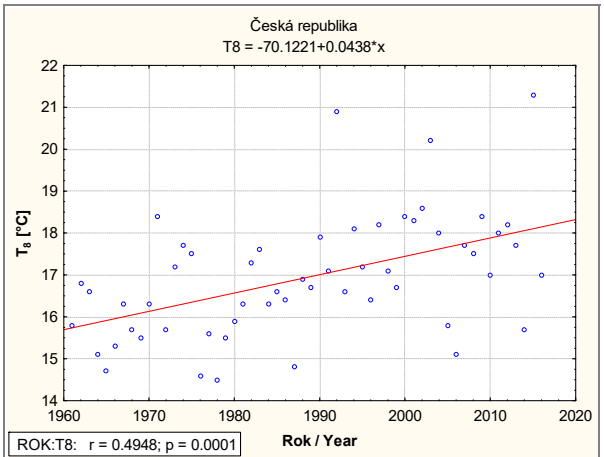

Figure S1-15. Territorial air temperatures in August

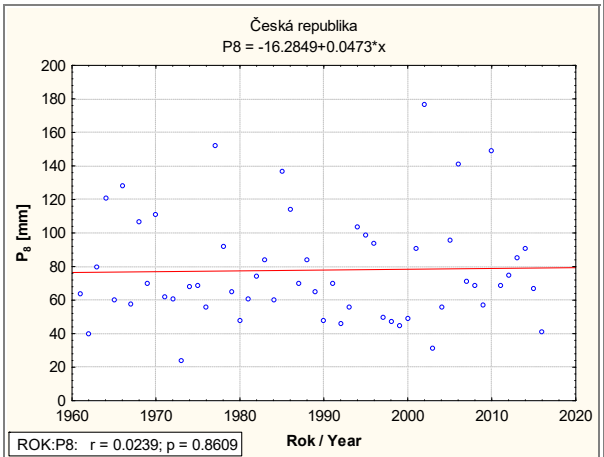

Figure S1-16. Territorial precipitation sums in August

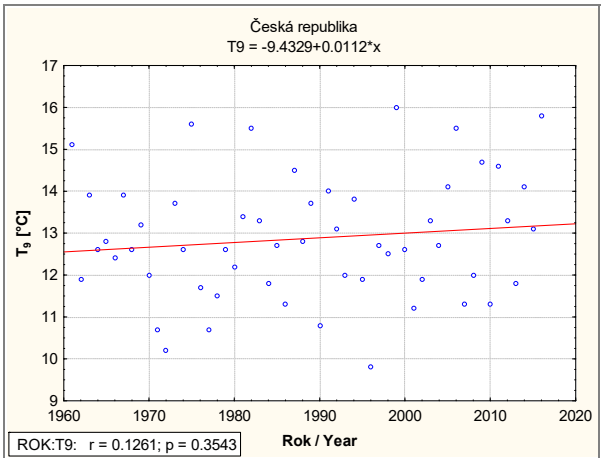

Figure S1-17. Territorial air temperatures in September

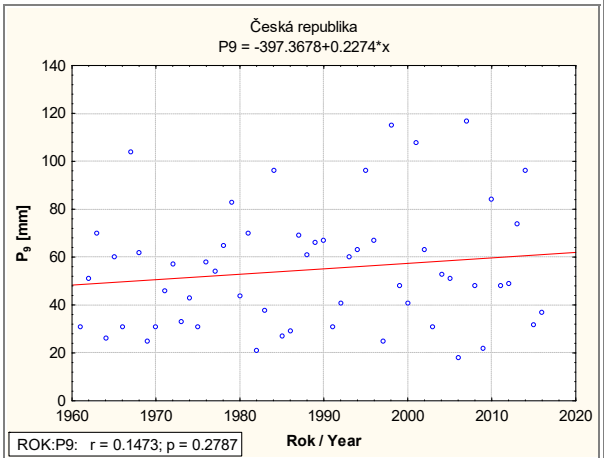

Figure S1-18. Territorial precipitation sums in September

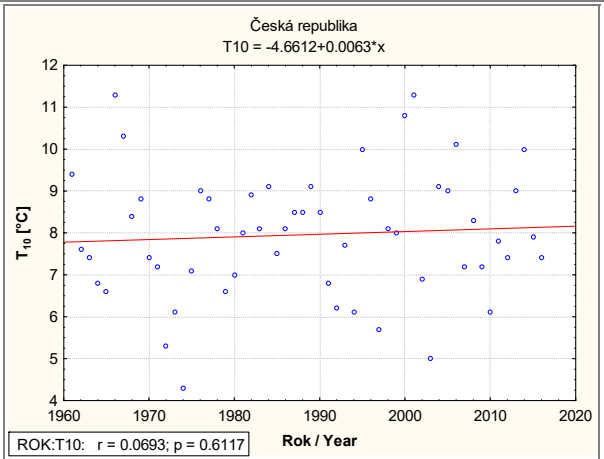

Figure S1-19. Territorial air temperatures in October

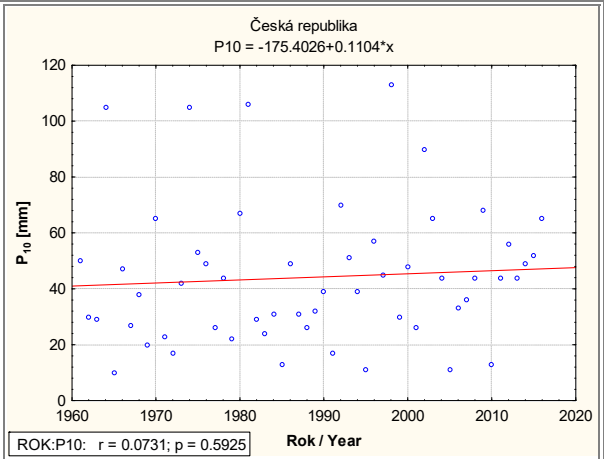

Figure S1-20. Territorial precipitation sums in October

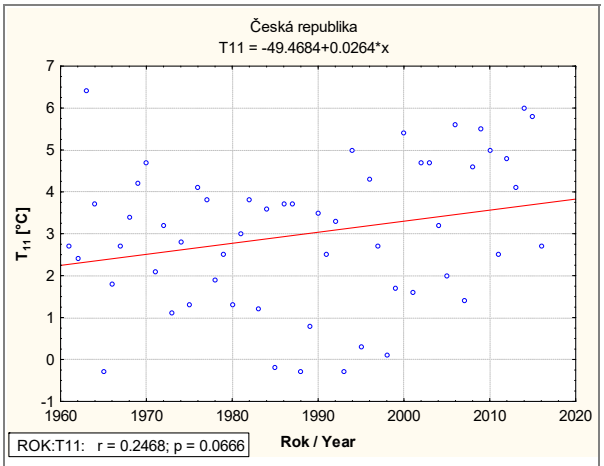

Figure S1-21. Territorial air temperatures in November

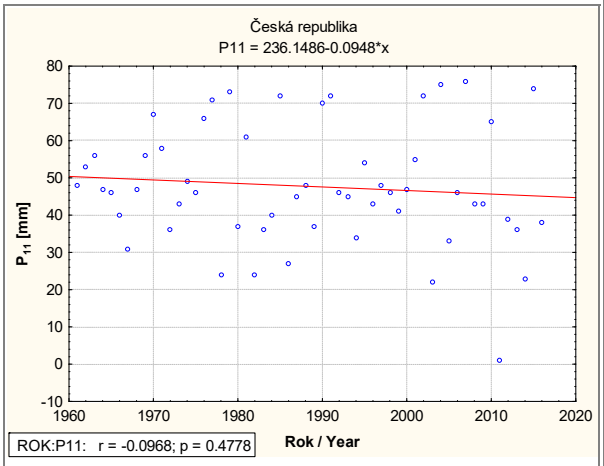

Figure S1-22. Territorial precipitation sums in November

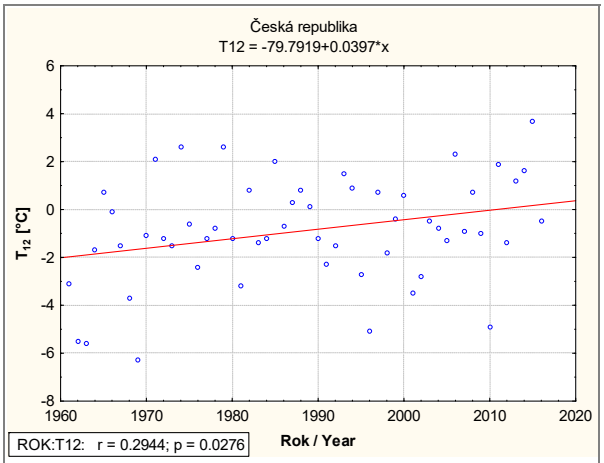

Figure S1-23. Territorial air temperatures in December

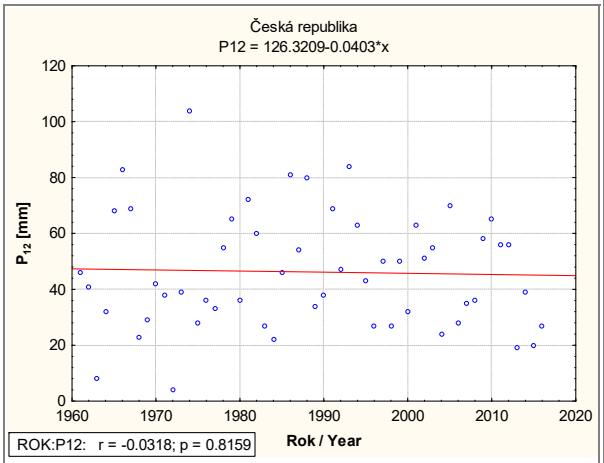

Figure S1-24. Territorial precipitation sums in December

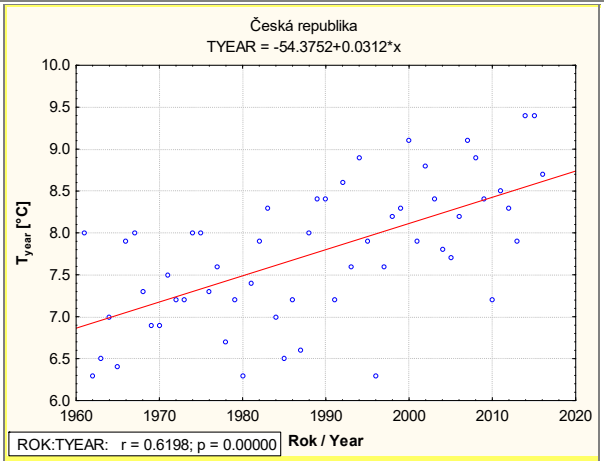

Figure S1-25. Yearly territorial air temperatures

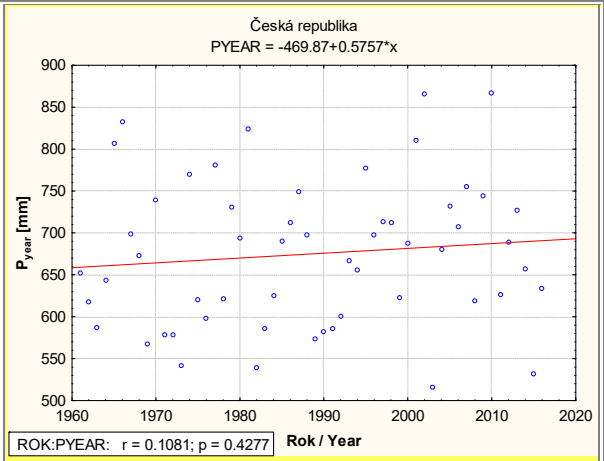

Figure S1-26. Yearly territorial precipitation sums

Differentiation of periods with distint climate character

Looking at the graph of average annual air temperatures, it can be seen that until 1982 the temperatures only oscillated around a certain average, but since 1983 they have been increasing. Therefore, it is appropriate to place the basic division of the period 1961–2020 between these two years. Analyses of the course of the weather at several meteorological stations of the ČHMÚ (Churáňov in the Šumava [MATĚJKA 2014], Labská bouda in the Krkonoše Mountains, Karlovy Vary - airport), carried out since 1983, have shown a statistically significant difference in the distribution of precipitation totals and in the occurrence of dry periods within two period: 1983-1994 and in the following years. Therefore, it is appropriate to place the second division of the observed period between the years 1994 and 1995. It is therefore possible to distinguish three periods for which the average characteristics were calculated - air temperatures (Table S1-1) and precipitations (Table S1-2).

The average annual air temperature varies significantly during these periods. However, the difference is not apparent in all months. A significant temperature difference is visible from April to August, i.e., during the entire growing season, then also in November. The smallest differences were recorded in September, when temperatures were most stable.

When comparing the total monthly precipitation sums, no significant difference can be found, both when looking at annual totals and for individual months. July appears to be the least stable, in which a slight decrease in precipitation totals was seen in the period 1983-1994 and, on the contrary, an increase in these totals in the following period. This last period also includes the two years 2002 and 2010 with the highest annual rainfall totals, as well as the two years 2003 and 2015 with the lowest totals. During the growing season (May – August), the driest years were 1990 (201 mm), 2015 (210 mm), 1992 (214 mm) and 2018 (215 mm). On the contrary, the highest rainfall totals in this period of the year were recorded in 2010 (475 mm), 1966 (447 mm), 2002 (409 mm) and 1965 (407 mm)

Table S1-1. Air temperature in three distinct periods since 1961 according to average territorial values for the Czech Republic (CHMI data) in individual months 1-12 and for the whole year. N - number of values, AVG - arithmetic mean, STD - standard deviation, P - error probability of F-test of one-factor analysis of variance (ANOVA).

Period		1		2		3		4		5		6		7		8		9		10		11		12		Year	
	N	AVG	STD	AVG	STD	AVG	STD	AVG	STD	AVG	STD	AVG	STD	AVG	STD	AVG	STD	AVG	STD	AVG	STD	AVG	STD	AVG	STD	AVG	STD
1961-1982	22	-3.14	2.47	-1.02	2.36	2.41	2.31	6.92	1.52	11.87	1.27	15.50	1.14	16.61	1.33	16.10	1.05	12.76	1.46	7.75	1.59	2.85	1.43	-1.45	2.46	7.25	0.58
1983-1994	12	-1.24	3.31	-1.80	3.33	2.85	2.47	7.59	0.92	12.73	1.77	15.08	1.11	17.74	1.68	17.16	1.46	12.82	1.14	7.85	1.02	2.21	1.87	-0.23	1.35	7.73	0.82
1995-2020	26	-1.63	2.39	-0.08	2.80	3.15	1.89	8.66	1.69	13.22	1.40	16.71	1.45	18.32	1.41	17.91	1.44	13.07	1.56	8.43	1.56	3.70	1.73	-0.36	2.20	8.42	0.77
1961-2020	60	-2.11	2.70	-0.77	2.80	2.82	2.16	7.81	1.68	12.63	1.54	15.94	1.44	17.58	1.61	17.10	1.53	12.91	1.43	8.06	1.50	3.09	1.73	-0.73	2.20	7.85	0.88
P(%)		6.95		18.4		50.6		**0.08**		**0.79**		**0.05**		**0.06**		**0.01**		74.6		25.4		**3.06**		25.9		**0.00**	

Table S1-2. Precipitation sums in three distinct periods since 1961 according to average territorial values for the Czech Republic (CHMI data) in individual months 1-12 and for the whole year. N - number of values, AVG - arithmetic mean, STD - standard deviation, P - error probability of F-test of one-factor analysis of variance (ANOVA).

Period		1		2		3		4		5		6		7		8		9		10		11		12		Year	
	N	AVG	STD	AVG	STD	AVG	STD	AVG	STD	AVG	STD	AVG	STD	AVG	STD	AVG	STD	AVG	STD	AVG	STD	AVG	STD	AVG	STD	AVG	STD
1961-1982	22	39.3	20.0	35.2	18.1	40.0	12.9	45.8	16.6	73.0	26.6	85.8	25.3	82.5	34.3	76.0	30.7	49.8	21.0	45.6	28.5	49.0	13.9	46.0	24.0	668.0	93.3
1983-1994	12	40.8	19.1	36.6	14.6	41.8	20.2	43.8	17.7	65.9	27.6	76.3	19.1	69.2	20.4	78.2	27.9	54.0	20.8	35.2	15.8	47.7	15.4	53.8	21.6	643.7	59.6
1995-2020	26	45.3	18.9	37.9	20.2	45.4	21.2	38.5	17.1	72.9	24.1	82.6	28.0	91.1	38.3	78.5	35.6	61.2	28.2	49.8	24.9	44.3	18.5	42.6	15.9	691.5	90.9
1961-2020	60	42.2	19.2	36.7	18.2	42.7	18.2	42.2	17.1	71.6	25.4	82.5	25.3	83.6	34.4	77.5	31.9	55.6	24.5	45.4	25.1	46.7	16.2	46.1	20.4	673.3	87.2
P(%)		54.5		88.0		58.3		31.8		70.0		58.7		18.7		96.0		27.3		24.9		59.4		29.7		27.7	

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