TERMINIŲ SEZONŲ POKYČIAI VIDURIO LIETUVOJE

Changes in thermal seasons in Central Lithuania

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Introduction

Temperature is one of the most important factors determining the plant growth conditions. The beginning of the plant vegetation is considered to be at the moment of constant air temperature (mean daily) transition through 5 °C in Lithuania, while active growth period of plants starts – when mean daily temperature constantly transits through 10 °C. The dates of these transitions in spring and autumn seasons vary from year to year.
Early spring and autumn frosts can cause substantial damage in the Lithuanian agricultural sector (Stuogė et al., 2012). Regional climate change is characterized through rising in mean seasonal air temperatures and changing frequency and seasonality of extreme weather events. Despite continuously warming climate over the last 50 years, the frost risk has increased in many regions (Menzel et al., 2020; Crimp et al., 2014).
Warming winters can lead to early onset of vegetation ("false spring") and increase the potential of agricultural frost in Central Europe as well as in Lithuania. Frost has been identified as a medium risk meteorological phenomenon that can lead the plant damage by reducing yields, yield and income (Ma et al., 2019; ASU, 2016).

Data and methods

- The main task of this study is to estimate the changes of dates of constant air temperature transition through temperature thresholds of 0 °C, 5 °C and 10 °C in transitional seasons.
- Also it was analysed changes in spring and autumn frost risk in Lithuania in whole warm season (April–October) from 1961 to 2018.
- As main variable there is used daily mean (t_{mean}) air temperature at standard (1.5 m) height in Dotnuva, Kaunas, Panevežys and Raseiniai meteorological stations (Figure 1).
- These stations are located in the most intensive agricultural region in Lithuania.

Figure 1. Location of study areas.

- The moment (date) of constant air temperature transition through temperature thresholds 0 °C, 5 °C and 10 °C degrees was indicate using constant daily mean air temperature transition.
- Also it was estimated an agricultural frosts changes in Dotnuva. Frost is considered when a minimum air temperature drops below +3 °C degrees during active (t_{mean}≥10)plant growth period.
- The detected changes were assessed using Sans-slope trend method and the Mann-Kendall test was used to assess the statistical significance of changes at α=0.05 significance level.

Results

Dates of constant air temperature transition through temperature thresholds.

- It was found that in the analyzed stations in 1981–2010, the cold season of the year (t_{mean}<0 °C) starts on average on 13–15 December and ends on 4–7 March (duration 81–84 days). The autumn transition was found to be below 0 °C in not all years analyzed.
- The vegetation season (t_{mean}≥5 °C) in the analyzed stations occurs in spring from 10 to 12 April, and in autumn (t_{mean}<5 °C) ends on 27–30 October. Accordingly, the season of active plant vegetation (t≥10 °C) starts from 30 April to 3 May and ending (t_{mean}<10 °C) from 30 September to 3 October. The duration of the vegetation season is 198–204 days, and the duration of active vegetation is 150–155 days (Table).

Table. The mean dates of constant air temperature transition temperature thresholds and changes in dates in 1961–2018. Statistical significant changes are marked in bold.

Station		0 °C			5 °C			10 °C		
		Spring	Autumn	Lenght	Spring	Autumn	Lenght	Spring	Autumn	Lenght
1981-2010 average	Dotnuva	03-05	12-13	82	04-10	10-30	203	04-30	10-03	155
	Kaunas	03-04	12-15	80	04-10	10-31	204	04-30	10-02	154
	Panevezys	03-05	12-15	81	04-11	10-29	201	04-30	10-01	154
	Raseiniai	03-07	12-15	84	04-12	10-27	198	05-03	09-30	150
1961-2018 change	Dotnuva	**-17,4**	**19,9**	**-37,5**	**-13,4**	-3,6	14	**-17,2**	**13,1**	**29**
	Kaunas	-15,5	13,0	**-31,1**	**-10,9**	-5,3	8,3	**-16,2**	8,9	**26,1**
	Panevezys	-16,0	**22,4**	**-40,8**	**-11,6**	-1,6	12	**-17,1**	**10,9**	**27,1**
	Raseiniai	-14,5	**27,0**	**-45,9**	-10,2	-9,1	3,6	**-13,4**	**12,6**	**24,9**

Changes of transition through temperature thresholds.

- 1961–2018 in the autumn, a steady transition below 0 °C became statistically significant between 13 and 27 days later, and in the spring – 16–17 days earlier. In general, the winter season shortened to 31–46 days
- Changes in the temperature transition over 5 °C are less significant and more pronounced only in spring – the transition occurs on 11–13 days previously at three stations.
- The most significant changes were found during the active growing season: the duration increased by almost a month (25–29 days).
- Assessing the changes in the dates of all temperature transitions, it is observed that the transition in spring is t_{mean}≥10 °C, and the transition in t_{mean}<0 °C is delayed in autumn. Smaller date changes at t_{mean}≥5 °C and higher t_{mean}≥10 °C suggest that the transition time in spring is longer when the average air temperature is between 0 and 5 °C and shorter when the air temperature is between 5 and 10 °C.
- The same trend is observed in autumn: the number of days between 10 and 5 °C transition dates decreases and between 5 and 0 °C increases.
- This shows that the duration of temperatures between 0 and 5 °C becomes longer in spring and autumn, and the transitions between 5 and 10 °C are more intense.

Frosts.

- The average number of days with frost (t_{min}<3 °C) in 1981–2010 in Dotnuva station found 4.2 days in spring and 2.5 days in autumn.
- During analysed period in 1961–2018, frosts did not occur during the spring (1963, 2003, 2006, 2009, 2018) and autumn (1965, 1967, 1981, 1988, 1992, 2006, 2007, 2011, 2012) of some years.
- The number of days with frost during active growth period on average has decreased by 3.2 days in spring and 2.8 days in autumn during last 58 years (Figure 1). These changes are statistically significant.

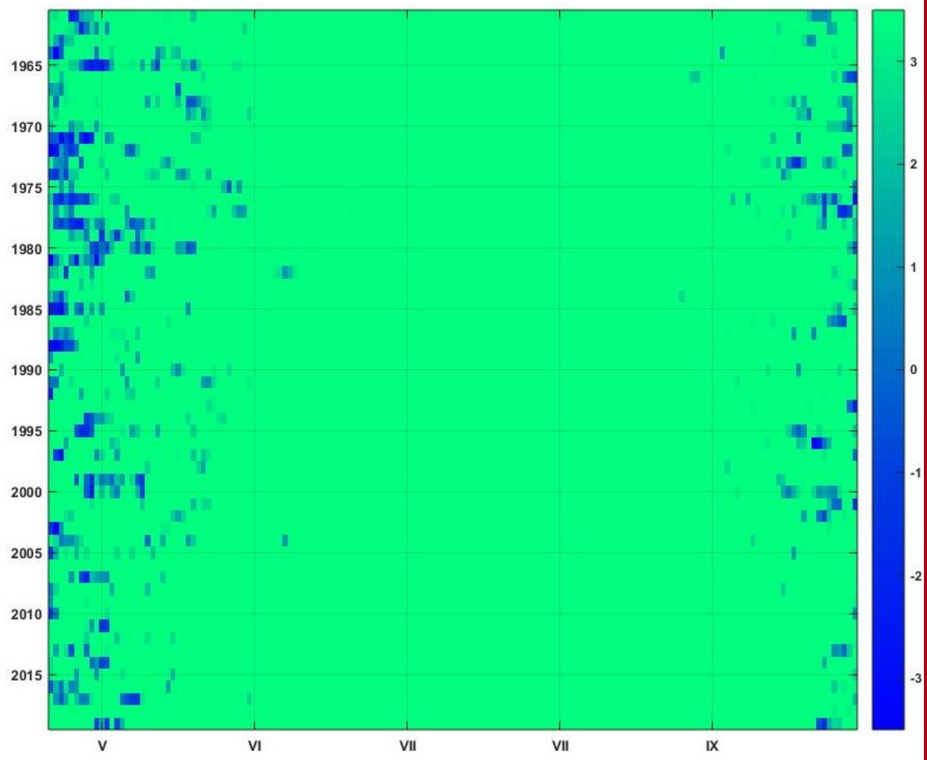

Figure 2. Hovmöller diagram of change of air temperatures (-3 °C – 3 °C) favored for agricultural frost formation in the warm season in Dotnuva of the year during 1961–2018.

Conclusions

- The results of the research show due to climate change, the length of active growth period of vegetation has increased by almost of one month. Statistical significant changes were found in spring dates of constant air temperature transition through 10 °C – they lag 17 days. The increased length of vegetation season allows growing crops in Lithuania for a longer period.
- It was also found that the number of days with frost decreased during the period analyzed. These results suggest that the prolonged active season of vegetation and the decreasing recurrence of frost are detrimental to some crops. On the other hand, prolonged periods of active vegetation and increasing precipitation volatility and drought frequency can adversely affect crops. This should be analyzed in the future.
- Seasonal changes in plant vegetation are important in agriculture because they also have an impact on agricultural practices. Climate change induced changes in the warm season not only pose new challenges for current crops, but also open up prospects for growing new species and varieties that prefer a longer warm season.

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