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Assessment of Fire Weather Conditions in Belarus under Modern Climate Warming †

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Abstract: The purpose of this study is to assess the fire weather conditions over the territory of Belarus during the warm season (March-October) for the period 1990–2020 using the monthly area-averaged data of Fire Weather Index (FWI). It is shown that the lowest seasonal average values of the FWI were observed in the Vitebsk and Grodno regions, the highest–in the Gomel region. The seasonal course of the FWI was characterized by increasing the average monthly values of the index from March to May, but in June a decrease of FWI values was observed. In July the index values reached a maximum. The obtained dynamics of the FWI indicates significant changes in the temperature and precipitation regime of the territory of Belarus in recent decades.

Keywords: Fire Weather Index; fire weather conditions; wildfires

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1. Introduction

The types of emergency situations associated with weather conditions include fires in forests, fields and peat deposits. Fires destroy and damage forests over large areas, which have a negative impact on the social and economic development of countries. A significant role in the occurrence of extensive fires is play by dry weather, stormy wind, etc. Current climate change in the central regions of Eastern Europe demonstrate an annual increase in air temperature and lengthening the warm season of the year that is potentially increases the period when wildfires may be observed [1].

The Republic of Belarus has extensive forest lands. The total area of tree plantations is 9.7 million ha; thus, the forest cover of the republic is 40.1% (2020). The most wooded regions are Vitebsk and Gomel regions (forest cover is 52% and 50% respectively) and the least forests-in the Grodno region (40%).

The territory of Belarus belongs to the region, in which wildfires occur annually. According to the National statistical committee of the Republic of Belarus (http://dataportal.belstat.gov.by), about 57 thousand wildfires with a total area of 121.7 thousand ha were observed in the country during 1990–2020. The area of dead forest plantations as a result of fires amounted to 44 thousand ha (1994–2020), and the amount of damage from forest fires averaged 260 thousand dollars/year, in some years reaching 720 thousand dollars (2017).

The fire weather conditions can be estimate and predict using various weather indices. Monitoring and forecasting of forest fires on the territory of Belarus are based on the indicator of forest fires by N.A. Dichenkov [2]. This method allows determining the period of fire occurrence under the forest canopy and the class of fire hazard according to weather conditions. The calculation of a complex indicator of forest fire hazard based on observations of air temperature, dew point temperature, the number of dry days, i.e., number of days without precipitation or with daily precipitation less than 2.6 mm. The scale of forest

burnability takes into account both the amount of precipitation for 10 days and the complex indicator of burnability. As can be seen from the Figure 1, the burnability classes determined by the upper row with the sum of precipitation of 3–14 mm in 10 days, by the middle row—15–25 mm, by the bottom—26 mm or more.

One of the most developed fire risk assessment systems in the world is the Canadian Forest Fire Danger Rating System (CFFDRS, https://cwfis.cfs.nrcan.gc.ca/background/summary/fdr). This system based on two subsystems–the Canadian Forest Fire Weather Index (FWI) System and the Canadian Forest Fire Behavior Prediction (FBP) System [3], both of which produce sets of indices of fire potential used in fire management activities.

The amount of precipitation for 10 days	THE FIRE DANGER LEVEL				
	1	2	3	4	5
	non-burnability of forests	Low burning of forests	Medium burning of forests	High burning of forests	Extreme burning of forests
Indicators of forests burning					
10 (3-14)	< 150	151-500	501-4000	4001-10000	10000 и >
20 (15-25)	<250	251-600	601-4000	4001-10000	10000 и >
26 and more	<350	351-700	701-4000	4001-10000	10000 и >

Figure 1. The Fire Danger Level (according N.A. Dichenkov).

The Canadian Forest Fire Weather Index System [4] consists of six components that account complex of weather conditions, and one of which is the Fire Weather Index (FWI) as a general index of fire danger in the forested areas. The FWI is a meteorological index, based on various components that take into account the influence of fuel moisture and wind in fire behavior and spread. Temperature, relative humidity, wind speed and 24 h accumulated precipitation is recorded at noon local standard time and used for the calculation of conditions at the site in late afternoon that is in the peak of fire danger.

The European Forest Fire Information System (EFFIS, https://effis.jrc.ec.europa.eu/) was adopted the Canadian Forest Fire Weather Index System as the method for assessing the fire danger level in Europe. The FWI was classifying in six classes (levels of fire danger): Very Low, Low, Moderate, High, Very High, Extreme and Very Extreme (Table 1). The fire danger classes are the same for all countries and apply in regions Europe, Middle East and North Africa. For comparison, in the Table 1 the classes also shown in accordance with CFFDRS.

The purpose of this study is to assess the fire weather conditions over the territory of Belarus during the warm season (March–October) for the period 1990–2020.

Table 1. The Fire danger classes (according to EFFIS and CFFDRS).

Hazard Rating	FWI CFFDRS	Hazard Rating	FWI EFFIS
Low	0–4	Very low	FWI < 5.2
Moderate	5–10	Low	5.2 ≥ FWI < 11.2
High	11–18	Moderate	11.2 ≥ FWI < 21.3
Very High	19–29	High	21.3 ≥ FWI < 38.0
Extreme	30+	Very High	38.0 ≥ FWI < 50.0

Extreme	FWI ≥ 50.0
Very Extreme	FWI > 70.0

2. Methods and Materials

The fire weather conditions in the Belarus estimated using the monthly area-averaged data of Fire Weather Index obtained from daily values in dataset of Fire danger indices historical data from the Copernicus Emergency Management Service, available through Copernicus Climate Data Store (https://cds.climate.copernicus.eu).

Additionally, in order to identify the compliance of the FWI with the intensification of real wildfires, three periods for different seasons with high fire danger weather and large-scale wildfires were considered: June 2015, August–October 2016 and April 2020.

The real forest fire data provided by the Republican Center for Emergency Management and Response (Belarus). Each fire event was included fire location with the area of ignition, occurrence time and consequences of fire (damage).

3. Results

The lowest seasonal average (March–October) values of the FWI were observed in the northern and north-western regions of Belarus–in the Vitebsk and Grodno regions (3.7–3.9), the highest–in the south-east of the country (Gomel region), with index values reaching 5.8, which corresponds to a low level of FWI [5].

The seasonal course of the FWI is characterized by increasing the average monthly values of the index from March to May (from the very low to the low category of FWI), but in June, a decrease of FWI values was observed in all regions of the republic. In July, the index values increased and reached a maximum in all regions–within the low level of FWI (6 … 9). From August to October, there was a gradual decrease of the average monthly values of index.

The study period was characterized by changing the repeatability of different levels of the fire weather in separate time intervals in all regions of the country (Figure 2). At the beginning of the period, in 1990–1994, the very low level of FWI prevailed from 80% of cases in the Vitebsk region to 73% in the Gomel region. In the next five-year period, the repeatability of FWI in the low category increased from 20 to 40%. In the last decade, the repeatability of the middle level of FWI has increased to 10–23%, only in the Vitebsk and Grodno regions a very low and low level of FWI prevailed. The high level of FWI was observed only in period 2015–2020 over the south of Belarus (Brest and Gomel regions) with a low frequency of 2%.

The FWI anomalies were calculated for determine the months with increased fire danger weather. Analysis of the dynamics of the FWI anomalies showed that in all regions of Belarus the months with negative FWI anomalies generally were dominated during the study period, but in some years the positive FWI anomalies were prevailed: 2002, 2007, 2011, 2014–2015, and in the period from 2018 to 2020.

There were 3 periods of large-scale fires in the Gomel region in 7–9 June 2015 and 12–15 (Khoiniksky district) and 13–18 (Lelchitsky district). During these periods, an increase in the values of the FWI was observed on the eve of fires with a maximum in the first two days of fires-up to 38 (high level) and 47 (very high) and a sharp decrease to a low and very low level in the following days.

A prolonged period of wildfires in the south of the country was observed from the end of August to the beginning of October 2016. The most severe fires were observed in the Stolinsky district of the Brest region from August 28 to 31, there in the temporary course of the FWI a maximum (36—high level) was observed on the second day of the fire and a decrease to moderate in the next. In the Lelchitsky district of the Gomel region, the period of fires on 13–17 September was characterized by the presence of FWI maxima (26—high level) on the first day of fires and a decrease in the following days.

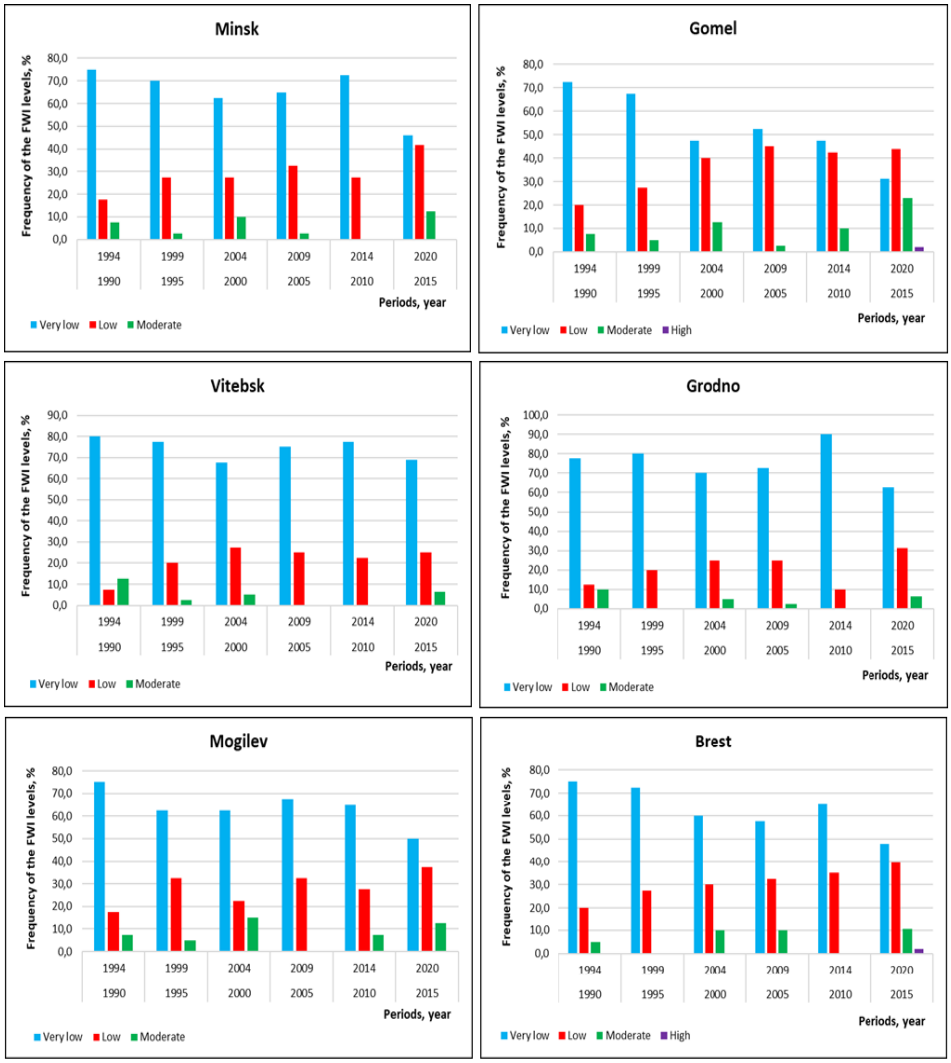

Figure 2. Dynamics of frequency of the FWI levels (%) in five-year periods during 1990–2020 in the regions of Belarus.

April 2020 was characterized by a shortage of precipitation in Belarus, in some places no more than 6–15% of the monthly norm. A large fire was recorded in the Stolinsky district of the Brest region from 5 to 11. The time course of FWI was characterized by a gradual increase in FWI values from 11 (moderate level) at the beginning of fires to 28 (high level)-on the last day.

4. Summary

The obtained dynamics of the FWI indicates significant changes in the temperature and precipitation regime of the territory of Belarus in recent decades, increasing the likelihood of fires in ecosystems. The increase in the repeatability of higher levels of fire danger weather occurs primarily in the southern areas of Belarus.

The FWI well reflect favorable weather conditions for the occurrence and spread of wildfires. Thus, the FWI can be recommended as an alternative to existing national fire weather assessment methods due to the high level of physical content of this parameter.

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