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Using the Weather Index Classification System for Canadian Forest Fires over the Al-Jabal Al-Akhdar in Libya

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ABSTRACT

Due to the noticeable change in temperatures in the world as a whole, fires in forests have become more prevalent in the summer. The current study sheds light on using the Canadian classification of forest burning on Al-Jabal Al-Akhdar in Libya, it aims to study the climatic variation of the fire weather index in Libya for the 24-27th day of July at noon for a long period 1940-2022. For Fire Weather Index (FWI) to occur, it is necessary to go through levels and analyze their data. The first level, which is the Fine Fuel Moisture Code (FFMC) code, is high in the middle and extends to the south of the region, while the Duff Moisture Code (DMC) code decreases in the north of the region and increases in the south. However, the Drought Code (DC) code shows the increase and decrease in the south as we head north, while in the second level, the Initial Spread Index (ISI) shows that it is high in the middle of the region. The Build-Up Index (BUI) increases to the south and decreases to the north, and for the occurrence of the Fire Weather Index (FWI) in the third level, it reaches above 60, and thus it is considered very high, and this was clear on the 24th and decreased on the 27th during the period 1940-2022 for July at 12 noon. When dividing the periods from 1940-1981 and 1982-2022, it becomes clear that the first period is more widespread than the second period, and the intensity of the second period is higher than the first period. This indicates climate change in temperatures and the occurrence of drought. Over the coming years, the fire weather index will increase in the future.

KEYWORDS: Climate change, Drought Code (DC), Duff Moisture Code (DMC), Fire Weather Index (FWI), Libya.

1. INTRODUCTION

Globally speaking, fire is the main cause of disturbance to terrestrial ecosystems. Climate, ecosystems, the cycles of carbon and water, and human activity are all closely related to it [1], so temperature, moisture, and wind the Weather elements that contribute to "hot, dry, and windy" weather conditions direct physical on wild land fires [2], which are a serious natural hazard on ecosystems and populations [3].

Wildland fires pose a serious threat to natural ecosystems in areas with a Mediterranean climate, causing enormous losses in terms of both economic and ecological resources [4]. The Mediterranean basin is particularly vulnerable to forest fires, with an estimated yearly average of over 50,000 fires burning an area roughly equivalent to 1.3–1.7% of all Mediterranean forests, but starting in the early 1970s, there has been a noticeable rise in the number of forest fires in Mediterranean basin regions where data dating back to the 1950s are available [5].

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According to the IPCC AR6 report, fire weather has changed in some regions (like the Mediterranean) compared to preindustrial times in terms of distribution, duration, and intensity. These changes are predicted to worsen as global warming levels rise [6].

In Libya, a rise in temperatures over the past years has caused several fires to break out in different areas and occasions, including the fire that broke out in an agricultural project near the city of Ghat, in the southwest of the country, which caused major material losses after a large number of palm trees burned in the year 2021 [7]. All global models indicated that the summer season is very hot, especially in North Africa during the year 2023, which makes the possibility of the outbreak of more fires possible, especially in forests and agricultural projects, this was evident in the eastern region, where a massive fire broke out in the Ain Mara Forest, due to high temperatures, as well as a huge fire that broke out in the Zala area in the south and caused widespread destruction, burning more than 800 palm trees.

Last summer, the city of Bani Walid, southwest of Tripoli, witnessed a major fire in the city's government hospital as a result of the explosion of the electrical control box due to high temperatures, which resulted in the fire igniting parts of the hospital, which contained many inmates, before it was brought under control. Without any human casualties [8].

2. OBJECTIVES OF THE STUDY

1. In recent years, it has been shown that temperatures have increased significantly in Libya during the summer months and its impact on the environment through the outbreak of fires.
2. To understand fire weather, knowing the weather factors that affect the size, intensity, and speed of forest fires, in addition to their predictability and their ability to expose society to danger.

3. SOURCE OF DATA

The ECMWF ERA5 reanalysis's weather forecasts from past simulations are used to calculate the fire weather index. The fire weather index is part of a dataset produced by the Copernicus Emergency Management Service (CEMS). The data was from day 24-27 of July at noon for the period 1940-2022[8].

Climatological Analysis of Fire Weather Index over Libya

In Libya, the climate is considered desert in most of the country, except for the areas overlooking the Mediterranean Sea, which take on the climatic characteristics of the sea [9]. When analyzing the data for most of the country, it became clear that the fire weather index in the south is very high, due to the high temperature and lack of rain, which consequently increases the expansion of drought areas in the country. We note that in the north of the country, it decreases more than in the south, but it is considered somewhat high, according to the classification of the fire weather index greater than (Extreme) 50 is considered high, as shown in Table 1 [10].

Upon analysis from the 24th to the 27th of July at 12 p.m. in the afternoon for the period 1940-2022, it became clear that the fire weather index increases in the south and decreases in the north, and the 24th is considered higher than the 25th, and this was clear in the eastern region, where there are trees represented in the Green Mountain area. It increases on the 26th and decreases further on the 27th. Therefore, the study was focused on using the Canadian Forest Fire Weather Index classification system over the Green Mountain area, which overlooks the sea and is characterized by vegetation.

Table 1. FWI value classification

FWI Danger	Level
very low	0-5.2
Low	5.2-11.2
middle	11.2-21.3
High	21.3-38
very high	38-50
Extreme	>50

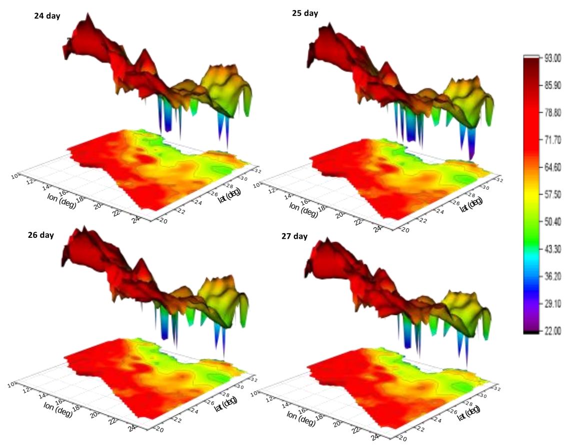

Fig. 1: Average Fire weather index (FWI) over Libya from 24-27 days at noon for July for the period 1940-2022, [8].

Area of Study

The spread of forests in the world and their burning every year in the summer months due to the noticeable climate change in rising temperatures has been an area of interest for many studies, the classification system has used the fire weather index for Canadian forests in the world as a whole. The Green Mountain region was among the regions of the world, (this is a region our study), at longitudes 21.2-22 and latitudes 31.19-33N^0. Although the fire weather includes all areas since these areas do not have vegetation cover, the burning speed is more evident in the forests, so it was concentrated more on the forests.

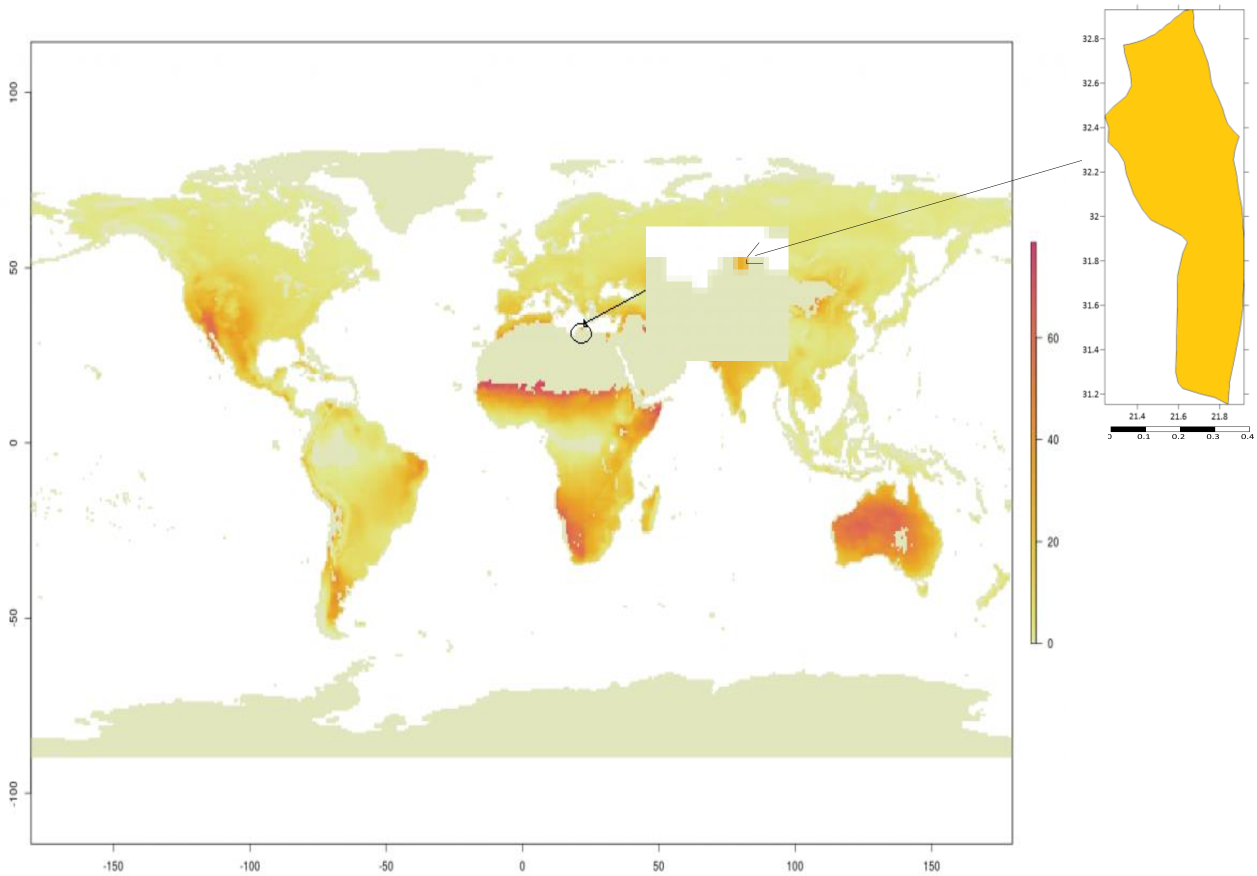

Fig .2: Area study Al-Jabal Al-Akhdar. mean FWI in the period 1980-2017[11].

4. METHODS

Fire Weather Index System

Definition The fire weather index indicates fire intensity by combining the rate of fire spread with the amount of fuel being consumed. The fire weather index is calculated using the Canadian Forest Service Fire Weather Index rating system (FWI) [12]. The fire danger model takes into account temperature, relative humidity, wind speed, precipitation, drought conditions, fuel availability, vegetation characteristics, and topography [13].

The FWI is calculated in three main tiers. In the first tier, three moisture codes are calculated. The Fine Fuel Moisture Code (FFMC) is calculated using temperature, precipitation, wind speed, and relative humidity. The FFMC represents moisture levels on daily time scales and in litter that is 2cm or less deep. The Duff Moisture Code (DMC) is calculated using temperature, precipitation, and relative humidity. The DMC represents moisture levels on ~2-week time scales and in litter and soil 5-10 cm deep. The Drought Code (DC) is calculated using temperature and precipitation. The DC represents moisture levels on ~2-month scales and in litter and soil 10-20 cm deep. All three moisture codes are unitless.

The second tier, the Build-Up Index (BUI) is defined as “a number that reflects the combined cumulative effects of daily drying and precipitation in fuels with a 10-day time lag constant” [13], and the Initial Spread Index (ISI) is calculated using the derived codes in the first tier. The BUI is calculated using the DMC and DC and represents the total fuel available for combustion through long-term drying. The ISI is calculated using the FFMC and wind speed to represent the rate of fire spread. In the third tier, the FWI is calculated using the BUI and ISI, and represents fire danger given the meteorological conditions, and the fire intensity, if a fire were to be ignited [15].

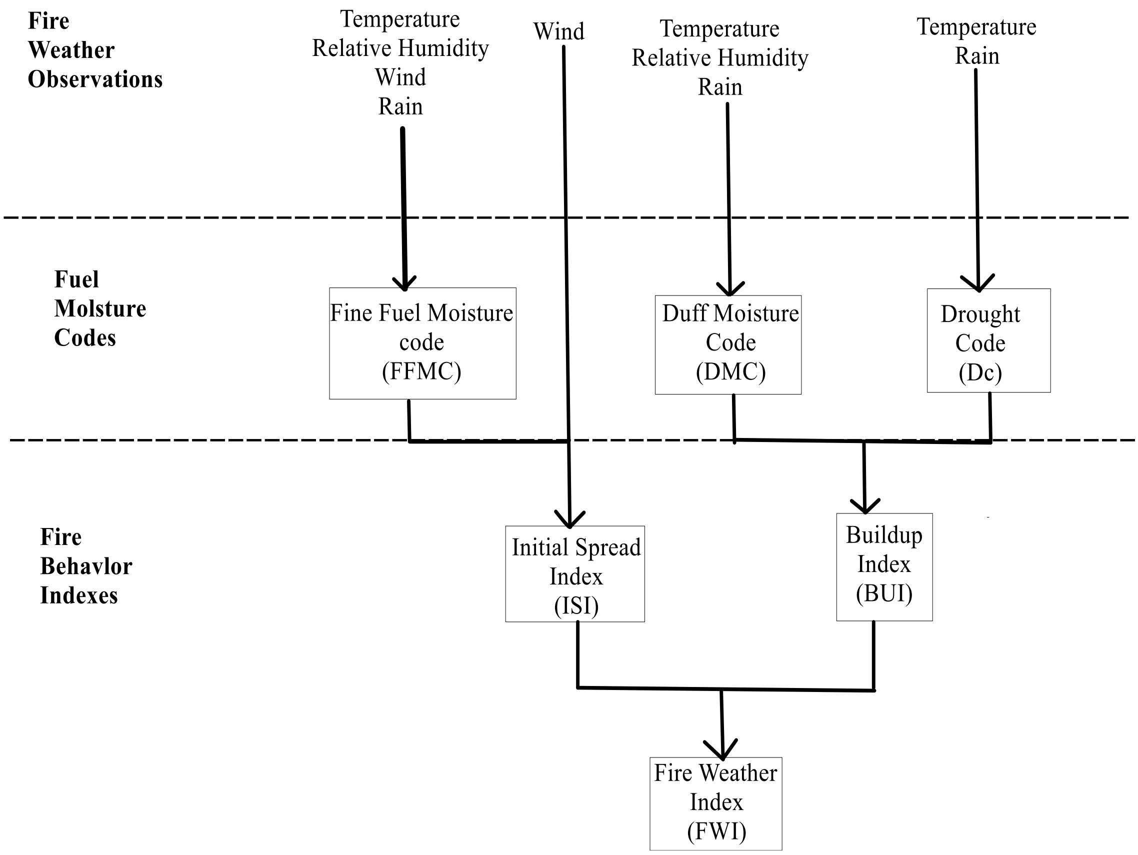

Fig .3: fire weather index system [12].

5. RESULTS AND DISCUSSION

Applying the Canadian classification for forest burning on the Green Mountain in Libya, which has a picturesque natural beauty and the density of its trees, which are concentrated in the center and south of the region more than in the north overlooking the sea. By analyzing the average Fine Fuel Moisture Code (FFMC) for each day from the 24^{th} to the 27^{th} at 12 in the afternoon for July during the period 1940-2022, it is clear that it increases in the south of the mountain and decreases in the north, and that its spread and density increases on the 26^{th} and then on the 27^{th} and decreases on the 24^{th} and 25^{th}, as shown in Figure (4, a), which shows the density function, the Fine Fuel Moisture Code for days, When calculating the total average from the 24^{th} to the 27^{th} at noon in July for the periods 1940-1981 and 1982-2022 to determine the increase, it became clear that the period 1982-2022 is more widespread and dense than the period 1940-1981, as shown in the Figure (4, b).

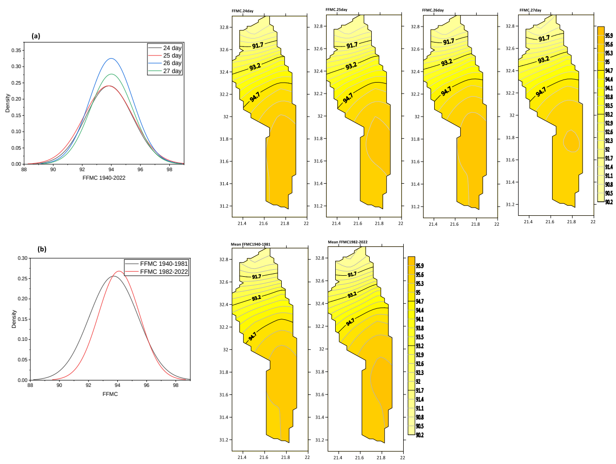

Fig. 4: Distribution and density of the average Fine Fuel Moisture Code (FFMC) over the Al-Jabal Al-Akhdar(a) 24-27 days at noon in July for the period 1940-2022, (b) 24-27 days at 12 noon in July for the period 1940-1981 and 1982-2022.

Figure (5.a) shows Duff Moisture Code (DMC) that increases in the south of the region and decreases as we rise higher. On the 27^{th} and 26^{th}, it is higher than on the 24^{th} and 25^{th}. Likewise, in the period 1940-1981, its density was higher, but less widespread than the period 1982-2022. As shown in Figure (5, b).

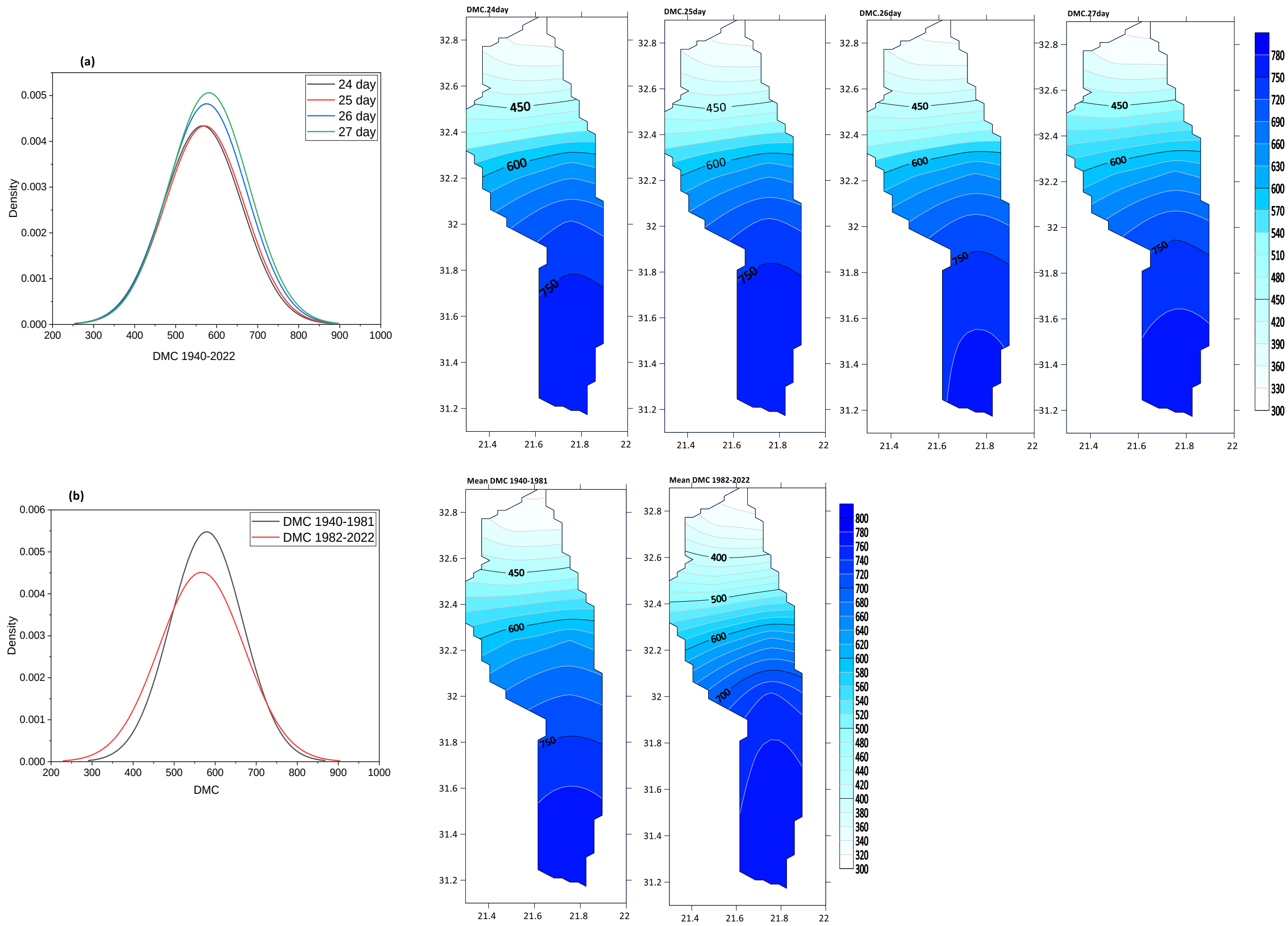

Fig. 5: Distribution and density of the average Duff Moisture Code (DMC) over the Al-Jabal Al-Akhdar (a) 24-27 days at 12 noon in July for the period 1940-2022, (b) 24-27 days at 12 noon in July for the period 1940-1981 and 1982- 2022.

In Figure (6, A) the average Drought Code (DC) is shown, showing its equal distribution for all days except Day 27. There is a very slight change, while for the period 1940-1981 it is more widespread and intense than the period 1982-2022 shown in Figure (6, B). This is due to climate changes and Rainfall amounts have increased in recent years, as forests are considered humid areas compared to other regions in the country, but the curve for the second period shows that it will increase during the coming years, and this is what climate models such as CMIP6 [16]. For the second level of the occurrence of the Fire Weather Index, the Initial Spread Index (ISI) is calculated. Shows that on the 24th at 12 noon in the month of July, the Initial Spread Index (ISI) , density was greater than the rest of the days, followed by the 25th and then the 27th in terms of density, but on the 26th it was greater in spread than on the 25th and 27th and less dense than them, as shown in Figure (7.a), while in Figure (7.b) it shows that the period 1940-1981 is more widespread and less intense than the second period 1982-2022, and this is what is shown by the drought code in Figure (6.b).

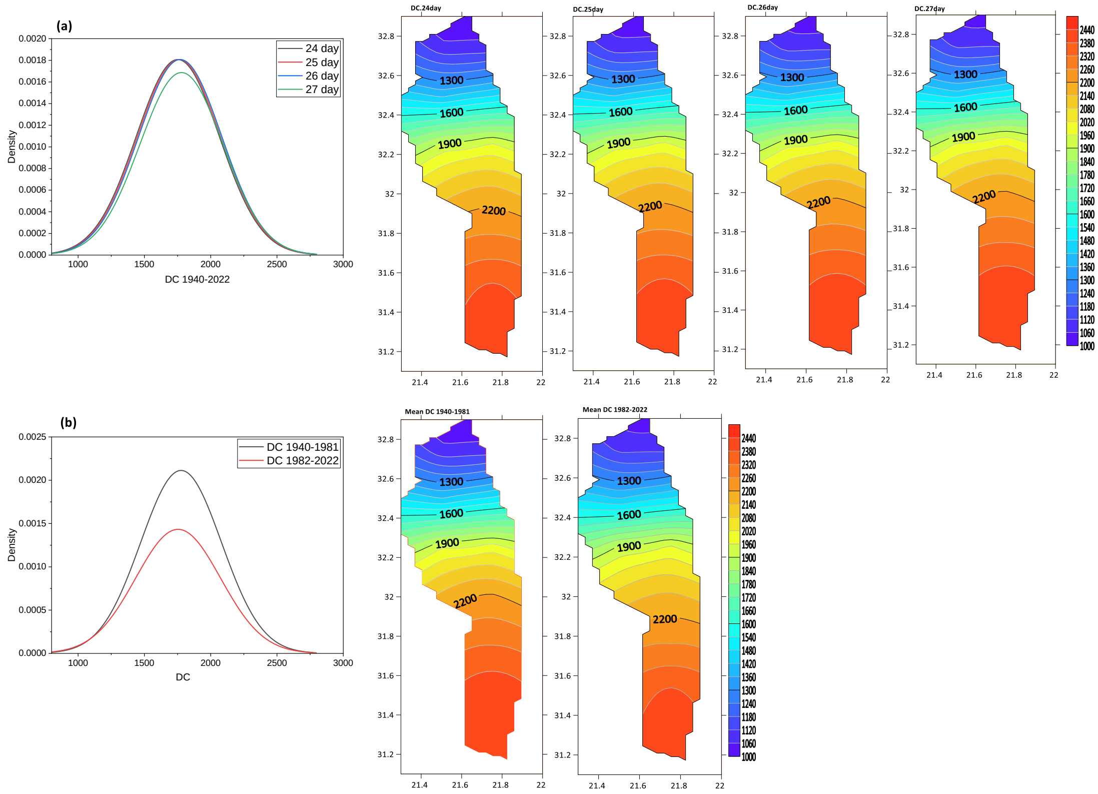

Fig. 6: Distribution and density of the average Drought Code (DC)over the Al-Jabal Al-Akhdar (a) 24-27 days at 12 noon in July for the period 1940-2022, (b) 24-27 days at 12 noon in July for the period 1940-1981 and 1982- 2022.

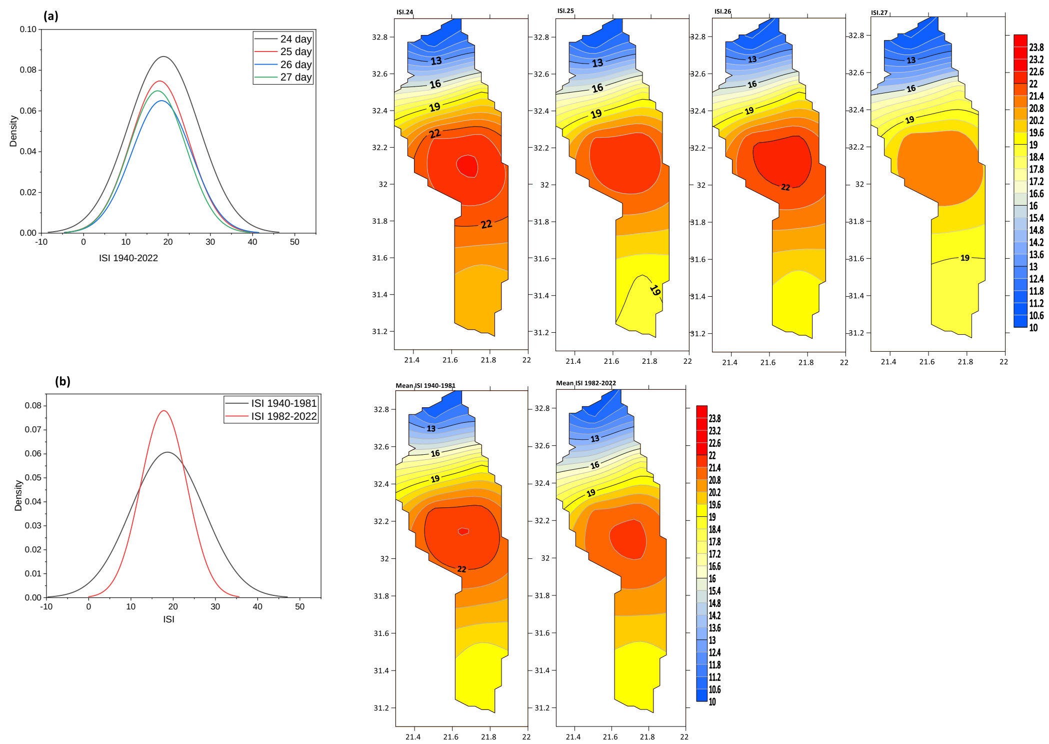

Fig. 7: Distribution and density of the average Initial Spread Index (ISI) over the Al-Jabal Al-Akhdar (a) 24-27 days at 12 noon in July for the period 1940-2022, (b) 24-27 days at 12 noon in July for the period 1940-1981 and 1982- 2022.

In Figure (8, a) the Build-Up Index (BUI) is shown. It is noted that day 26 is more widespread than days 25 and 27, and day 24 is less dense. While analyzing the periods in Figure (8, b), we see that the period 1982-2022 is more widespread and less dense than the period 1940-1981.

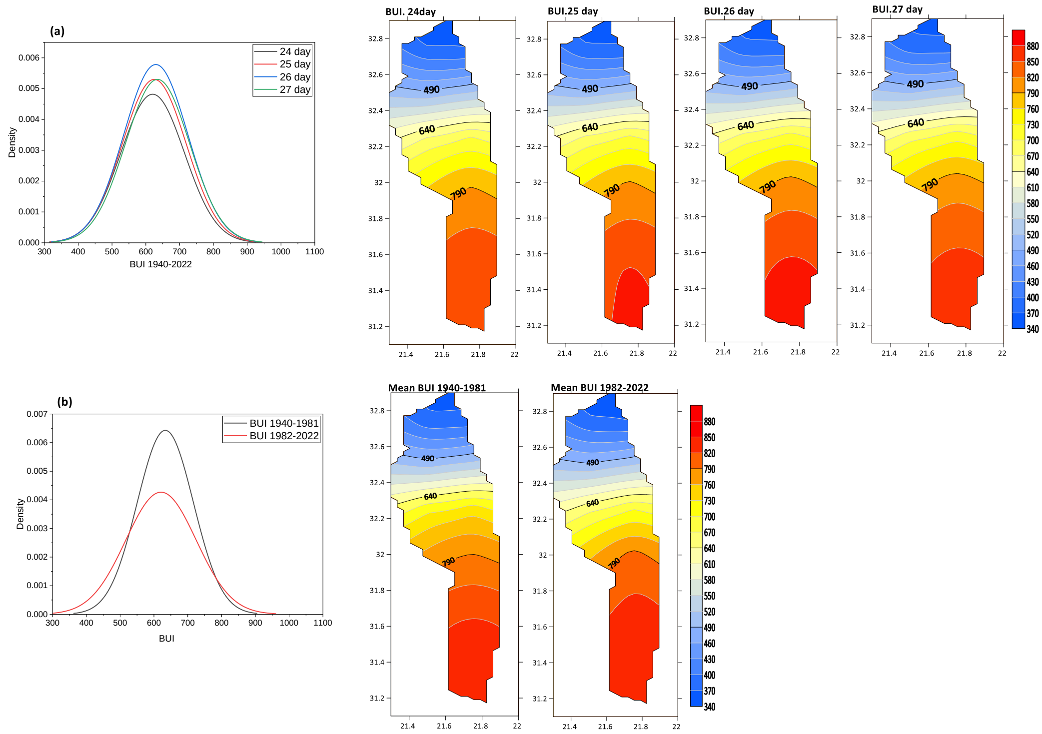

Fig. 8: Distribution and density of the average Build-Up Index (BUI)over the Al-Jabal Al-Akhdar (a) 24-27 days at 12 noon in July for the period 1940-2022, (b) 24-27 days at 12 noon in July for the period 1940-1981 and 1982- 2022.

At the last level, the Fire Weather Index (FWI) was the highest possible and most widespread on days 24 and 26, reaching a value of more than 60 from the south of the region to its center, and decreasing as we headed towards the north, followed by the 25th, while the 27th was less widespread, as shown in Figure (9, a). While it is noted in Figure (9, b) that the period 1940-1981 is more widespread than the period 1982-2022, with the passage of the coming years, the intensity of fire weather increases, and this is shown in the intensity curve for this period.

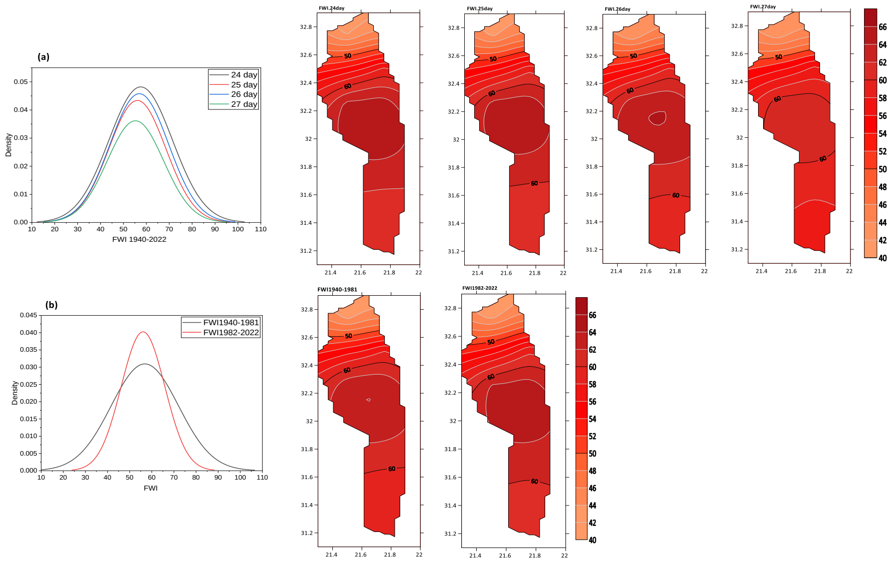

Fig. 9: Distribution and density of the average Fire Weather Index (FWI) over the Al-Jabal Al-Akhdar (a) 24-27 days at 12 noon in July for the period 1940-2022, (b) 24-27 days at 12 noon in July for the period 1940-1981 and 1982- 2022.

To know the increase and decrease in the Fire Weather Index (FWI), for Canadian classification, the difference between the periods 1940-1981 and 1982-2022 was taken. It is noted that the FFMC code increases in the south of the region and decreases in the north, while the DMC code increases in the north and gradually decreases in the south. On the other hand, the DC code increases in the south and decreases in the north. Whereas the ISI code increases in the middle of the region, it decreases in the north and south. The BUI code, however; it decreases in the central part and extends to increase in the north and increases somewhat in the south, and the FWI is highest in the center of the region and decreases towards the north, where there is less vegetation cover and marine climate. See Figure 10.

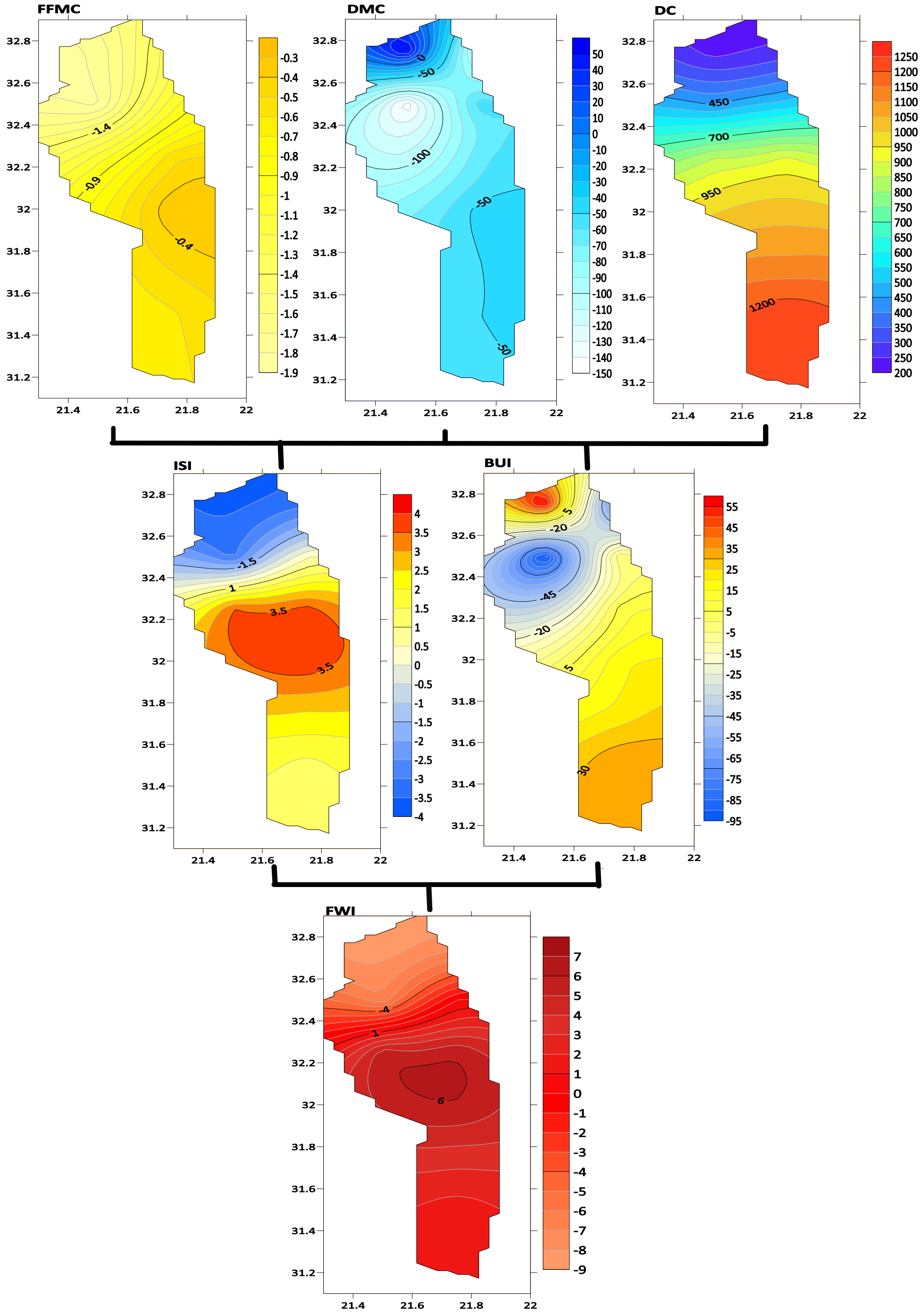

Fig. 10: The difference between the period 1982-2022 and the period 1940-1981 for the Canadian classification of the Fire Weather Index over the Al-Jabal Al-Akhdar for the 24-27 days of July at 12 noon.

6. CONCLUSION

Climate change has become clear in terms of an increase in temperatures across both continents and oceans, resulting in floods in some countries and, on the other hand, the spread of fires in other parts of some countries. Here in this study, the Canadian classification for burning forests in the Green Mountain region was used, has it dense with trees, although Libya considers the fire weather index to be very high in all of Libya, but when this classification is used on forests to reach the fire weather index (FWI), it requires measuring all of the following: The first level, which is the Fine Fuel Moisture Code (FFMC), is high in the center and extends to the south of the region, and it was more evident in On the 26th, compared to the rest of the days, its spread and density are high, while the Duff Moisture Code (DMC) decreases in the north of the region and increases in the south, and it was clear on the 27th day, then on the 26th, and its spread in the period 1982-2022 is more than the period 1940-1981, while the Drought Code (DC) shows the increase and decrease in the south as we headed north and its spread in the period 1940-1981 was higher than the period 1982-2022 due to the increasing amounts of rain in recent years, but its spread will increase and this is shown in the curve for the second period due to the increase in temperature and lack of rain in the coming years, while in the second level The Initial Spread Index (ISI) shows that it is high in the middle of the region, and the Build-up Index (BUI) increases to the south and decreases to the north, and due to the occurrence of fire weather (FWI) at the third level, it reaches above 60, and thus it is considered very high, shown on the 24th and 26th days more than on the 25th and 27th days.

Because of the Intergovernmental Panel on Climate Change) IPCC) warnings of climate changes on the Earth's surface, the fire weather index will increase in the coming years, and the Libyan state must take caution and be careful of these changes in the future.

Author Contribution: The design of the study, the analysis of the data and the final results and conclusion have been carried out by the author.

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Data Availability Statement: The climatic data used in this research paper was obtained from

https://cds.climate.copernicus.eu/

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Conflicts of Interest: The author affirms that they have no known financial or interpersonal conflicts that would have appeared to have an impact on the research presented in this study.

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