Evaluating present and future fire risk due to climate change in the Mediterranean: A case study for Greece

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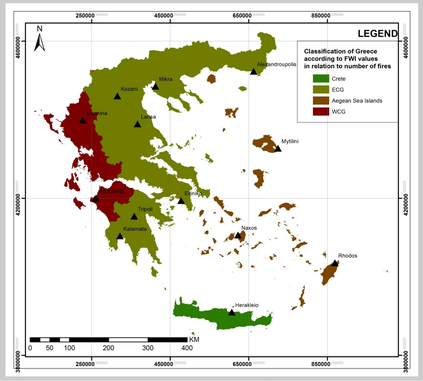
1. Aim and Methodology

In this study, an evaluation of FWI index is initially performed for the Greek territory using fire observations that cover a 15-year period. Subsequently, a regional climate model is used to provide input for the FWI system in order to investigate the impacts of climate change on fire risk for two future time periods: 2021-2050 and 2071-2100. The fire data used, were provided by the Forest Special Secretariat of the Ministry of Environment, Energy & Climate Change. Fire data inventory of forest fires that occurred in the period 1983-1997 throughout Greece. Meteorological data for 11 stations covering the same 15-year period were obtained from the Hellenic National Meteorological Service. Data was used only for the fire season (April-October) and mean daily values from the meteorological stations were used in order to compute daily values of FWI.

2. Forest Fire Records

The Table below presents cumulative data on the number of fires (NOF) occurred and the burned area (BA-Ha) in all four domains for each month in the period 1983-1997 as shown in the reference map. Burned Area is represented as a percentage of the entire domain area, and the number of fires as a ratio of fire per 10.000 ha. The data indicate that the burnt area and the number of fires of the West Domain and in Crete are significantly higher than in the other domains.



Domains	Crete				West				Islands				East			
	BA	NOF	Avg. Prec	Avg. RH%	BA	NOF	Avg. Prec	Avg. RH%	BA	NOF	Avg. Prec	Avg. RH%	BA	NOF	Avg. Prec	Avg. RH%
Apr	0,0273%	0,3474	23,36	60,02	0,0843%	0,8072	57,52	70,19	0,0199%	0,5305	54,35	68,24	0,0560%	0,5433	47,81	65,17
May	0,0795%	0,5631	11,51	58,85	0,0568%	0,6010	38,09	66,73	0,1175%	0,6345	14,07	67,60	0,0276%	0,4973	29,71	60,45
Jun	0,5664%	2,4560	4,66	55,29	0,1239%	1,5662	22,40	61,30	1,0265%	1,7370	2,46	64,05	0,3724%	1,1403	22,04	52,80
Jul	2,2762%	4,8881	1,29	56,30	1,9851%	5,5323	19,74	59,16	3,2852%	3,1931	0,75	63,72	1,6438%	2,3978	18,87	50,04
Aug	2,8377%	5,3674	0,01	59,03	3,0526%	10,3406	19,41	61,99	5,7907%	2,9331	0,80	66,16	1,9370%	2,8940	18,34	52,58
Sep	1,6557%	7,7755	7,51	60,32	1,1725%	7,0853	35,45	66,99	1,7181%	2,3090	3,73	66,37	1,1467%	2,7089	15,63	57,30
Oct	0,8081%	5,0199	51,84	64,81	0,2985%	3,6501	114,98	72,55	0,4016%	1,9762	44,45	70,29	0,3630%	1,4284	43,77	66,45

3. FWI Evaluation

Forest fire risk was assessed using the Canadian Fire Weather Index (FWI). The FWI System provides numerical ratings of relative fire potential based solely on weather observations. FWI components depend on daily noon measurements of dry-bulb temperature, air relative humidity, 10m wind speed and 24 h accumulated precipitation.

FWI consists of 6 standard components each measuring a different aspect of fire danger. The first three are fuel moisture codes that follow daily changes in the moisture contents of three classes of forest fuel with different drying rates. The remaining components are fire behavior indices representing the rate of spread, fuel weight consumed and fire intensity.

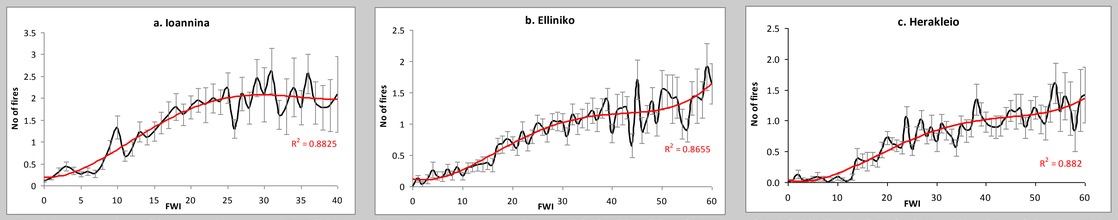


Fig.1 Mean number of fires per day against FWI (black line) and the respective polynomial fit (red line) for a) Ioannina (WCG), b) Elliniko (ECG), c) Herakleio (Crete) for the 1983-1997 period.

A pattern seems to emerge from the results analysis which classifies the domain into two distinct areas of different fire behaviour; the Western and Eastern Continental Greece (WCG and ECG), respectively. Specifically, in WCG one fire per day occurs when FWI=15 (Fig. 1a), while in ECG the same is true when FWI=30 (Fig. 1b). This rate of occurrence can be considered as extreme fire risk. Crete exhibits a different behaviour, as an elevated fire risk (i.e. about one fire every two days) occurs for FWI≥30, while the extreme fire risk (i.e one fire per day) occurs when FWI≥40 (Fig. 1c). The results for the islands of the Aegean do not seem to fit into a pattern as they show great variability in the relationship between fire events and FWI values, probably due to the complex local terrain and the small number of fire events (not shown).

4. FWI sensitivity test

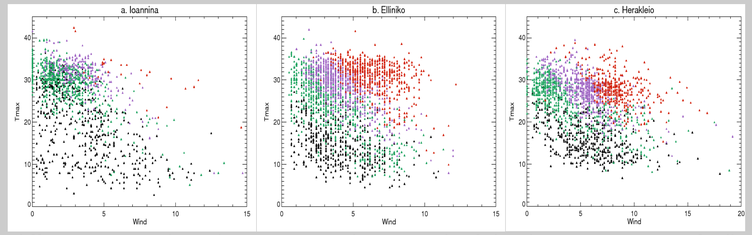
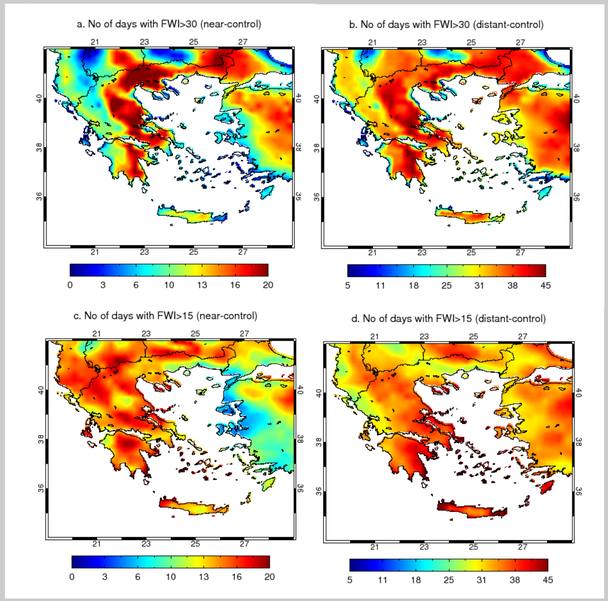


Fig. 2. FWI as function of wind speed and temperature for days with r<1mm and rh<60% for a) Ioannina (WCG), b) Elliniko (ECG) and c) Herakleio (Crete); blue for FWI <15, green for 15≤FWI<30, violet for 30≤FWI<45, red for FWI≥45.

This distinct behaviour can be attributed to the different meteorological regimes prevalent in each of the three regions. Specifically, WCG is characterized by high precipitation amounts (resulting in higher fuel moisture content), while in ECG and Crete, precipitation amounts are substantially lower and dry northern winds mostly prevail during the warm period of the year. An evidence of the above is the distribution of the FWI as a function of the meteorological parameters; here as a function of wind speed and temperature (Fig. 2) for days without rain (r<1mm) and with low relative humidity (rh<60%). The distribution is shifted to lower wind speed values and FWI takes substantially lower values for Ioannina (in WCG) compared to Elliniko (Athens, in ECG). In Herakleio (Crete) the wind speed receives even higher values (Fig 2c) contributing to the high index values.

5. Future Projections

Present and future model data from the Regional Climate Model RACMO2 were used in this study. The model was developed within the framework of the ENSEMBLES Project, by the Royal Netherlands Meteorological Institute (KNMI), at 25km horizontal resolution. The control run represents the base period 1961-1990 and is used here as reference for comparison with future projections for the periods 2021-2050 and 2071-2100.



Eastern Continental Greece (ECG)

- In the near future (2021-2050) an increase of up to 20 more days of extreme fire risk (FWI>30) per year is expected (Fig 3a).
- By the end of century even greater increases are evident, reaching 45 more extreme fire risk days per year (Fig. 3b).
- The most notable increases are estimated in the Attica peninsula, Eastern Peloponnese, Central Macedonia and Thessaly.

Western Continental Greece (WCG)

- In the near future increase reaches 20 more days with extreme fire risk per year (Fig 3c).
- The increase is higher for the distant future (2071-2100), with values ranging between 25-40 days (Fig. 3d).

Fig. 3. Projected changes in the number of days with extreme fire risk during near future (left) and distant future (right), for ECG (top) and WCG (bottom).

6. Conclusions

- The values of FWI indicating extreme fire risk (one fire per day) vary spatially, increasing as we move from the north-west to the south-east of Greece.
- Two threshold values of extreme fire risk (defined as one actual fire event per day) can be established; FWI ≥ 15 for western continental Greece and FWI ≥ 30 for eastern continental Greece.
- Future projections suggest a general increase in fire risk over the domain of interest, ranging between 25 and 45 more days of extreme fire risk per year by 2071-2100 in the western and eastern parts of Greece, respectively.

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