# Fire weather assessment of future changes in fire weather conditions in the Attica region

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**Abstract:** During the last few decades, Greece has experienced significant and numerous wildfires with great impact on ecosystems, archaeological sites, infrastructures and people 'lives. Under the framework of the European project "FirEUrisk" aiming at establishing an evidence-based strategy to create resilience against European wildfires and improved fire management under a changing climate, the present work aimed to assess for the first time in the high resolution of 5km, the future changes in fire weather conditions in Attica region. For this purpose, a methodology was applied to investigate the projected changes in fire weather conditions under RCP4.5 and RCP8.5 emission scenarios The fire weather assessment was based on Fire Weather Index (FWI), Initial Spread Index (ISI) and threshold-specific indicators for the Attica region. The indices were calculated from climate datasets derived from high-resolution validated simulations. The results highlighted areas of the region that are most prone to wildfire danger under a changing climate.

## Methodology and Model setup

The dynamical downscaling technique was applied through the non-hydrostatic WRF model (version 3.6.1) [1]. The spatial configuration (Figure 1a) along with the description of the model setup can be found in detail in [2–6]. These extensively attentive validation studies proved the credibility of the downscaling process of capturing the historical spatio-temporal patterns of climate variables. The initial and boundary conditions were derived from the EC-Earth model [7] climate simulations for RCP4.5 and RCP8.5 [18,19] and encompassed time slices representative of the historical or reference (1980–2004), near future (2025–2049), and far future (2075–2099) periods.

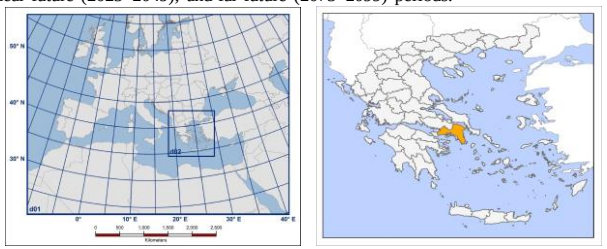


**Figure 1.** Modelling Domains: d01 refers to Euro-Mediterranean region 20 km and d02 to the nested domain of 5 km (region of Greece) (left). Area of Greece, in orange color for the Attica region (right).

| Physics Parameterizations | |
|---|---|
| Microphysics | WSM6, Hong and Lim 2006 |
| Long wave radiation | RRTMG, Iacono et al. 2008 |
| Short wave radiation | RRTMG, Iacono et al. 2008 |
| PBL | MYJ , Janjic 2001 |
| Surface layer | MO, Mellor and Yamada 1982 |
| Cumulus | BMJ, Betts and Miller 1986 |
| Land Surface Model | NOAH, Chen and Dudhia 2001 |

The approach for the estimation of fire weather conditions in this study followed the method based on Percentiles Indices. This method, proposed by Varela et al. 2018 [8], provides suitably varying FWI boundaries of classes that consider the specific physical characteristics of the study area at high resolution, compared to EFFIS classification (https://effis.jrc.ec.europa.eu/).

**Table 1**. The classification of values for the FWI and its sub-component ISI.

| FWI classes by EFFIS | FWI Percentiles by Varela et al. (2018) | ISI classes BY EFFIS |
|---|---|---|
| Very low (<5.2) | | Very low <3.2 |
| Low (5.2-11.2) | Low 25th percentiles | Low 3.2-5 |
| Moderate (11.2-21.3) | Moderate 50th percentiles | Moderate 5-7.5 |
| High (21.3-38) | High 75th percentiles | High 7.5-13.4 |
| Very high (38-50) | | Very high 13.4-30 |
| Extreme (>=50) | Extreme 90th percentiles | Extreme >30 |

## Results

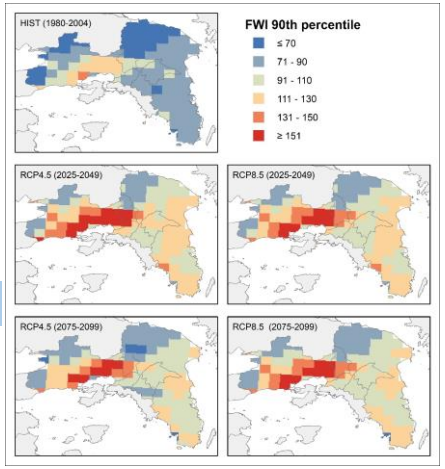


**Figure 2.** FWI threshold value of the 90th percentile for the historical and future periods for each emission scenario for the Attica region.

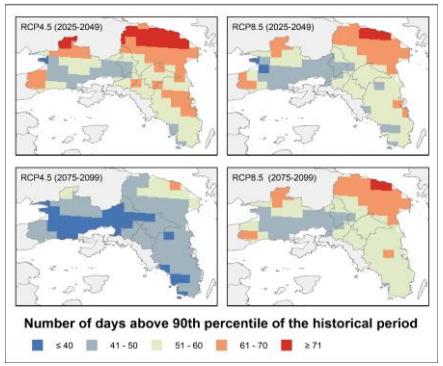


**Figure 3.** The number of days above 90th percentile (threshold value is set as 90th percentile of the historical period for the specific cell for all time periods) under the future emission scenarios in the near and far future periods for the Attica region

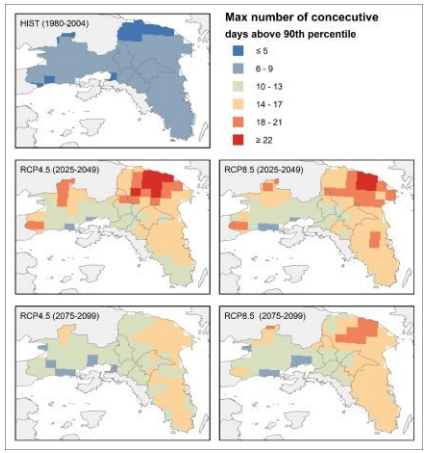


**Figure 4.** The maximum number with consecutive days above 90th percentile (threshold value is 90th percentile of the historical period for the specific cell) for historical period and RCP4.5 and RCP8.5 for the near and far future periods for the Attica region.

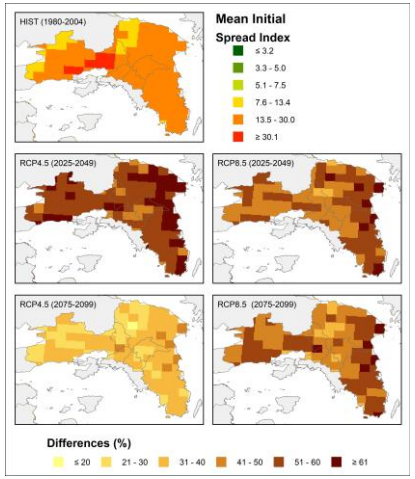


**Figure 5.** The mean value of Initial Spread Index for the historical period (top map) and future changes under RCP4.5 and RCP8.5 (in %) for the near and far future periods with respect to the historical period (middle and bottom maps) for the Attica region.

## Conclusions

- Figure 2: During the historical period, values of the extreme percentile (FWI90) between 50 and 70 are observed in the north Attica region, while values of FWI90 greater than 75 are observed over the rest of the region, with higher values in the western part of the region. In the future periods, large increases of FWI90 are observed, during all periods and under both emission scenarios and with the stronger changes focusing on the eastern and western parts of the Attica region.
- The increase in the number of days (Figure 3) above FWI90 is more evident in the near future period in both scenarios and in the far future period under RCP8.5. It is also estimated that the northern parts of the Attica region will encounter more than 70 days of extreme fire weather during the fire seasons that correspond to a future change of an increase of more than 45 days compared to the historical period. The other part of the region will experience between 41 to 70 days of extreme fire weather with an exception during the far future and under RCP4.5 where less than 40 days are observed in the central western part of the region
- The north-eastern part of the Attica region will experience a higher future change in extreme consecutive fire weather days (Figure 4), of above the 90th percentile of the historical period, (with above 22 days), compared to the historical period in the near future. It is also observed that more than 14 consecutive days of extreme fire weather are expected during all periods and scenarios in the eastern Attica region.
- Figure 5: Future changes of the ISI: a major part of the Attica region is characterized by a high initial spread index to very high in the western part during the historical period. A change of more than 50% of ISI over almost the entire region (more than 60% in the east Attica region) in the near future under RCP4.5, while this change is restricted in the eastern Attica region under RCP8.5 in both periods. Finally, the lower changes are noticed in the far future and under RCP4.5.
- The complex topography of Greece (Attica region included) and its particularly diverse climatic conditions present challenges when using fixed FWI thresholds, which can lead to either overestimation or underestimation of fire danger in certain regions as has been pointed out by Varela et al 2018. Thus, the study examined the application of the new method based on Percentile Indices that considers the unique physical characteristics of the study area along with the use of high spatial resolution climate data. This effort focusing on Attica region could provide more accurate FWI boundaries for different classes and consequently a clear benefit to the derivation of fire danger patterns under a changing climate. Consequently, this information could be taken into consideration by forest fire authorities in fire management planning

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