Very high fire danger in UK in 2022 at least 6 times more likely due to human-caused climate change

Chantelle Burton[1], Andrew Ciavarella[1], Douglas I. Kelley[2], Andrew Hartley[1], Mark McCarthy[1] , Stacey New[1] , Richard A. Betts[1,3], Eddy Robertson[1]

[1]Met Office Hadley Centre, Exeter, EX1 3PB

[2]UK Centre for Ecology and Hydrology

[3]Global Systems Institute, University of Exeter

Corresponding author(s): Douglas I. Kelley (doukel@ceh.ac.uk), Chantelle Burton (chantelle.burton@metoffice.gov.uk)

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Abstract

The UK experienced an unprecedented heatwave in 2022, with temperatures reaching 40°C for the first time in recorded history. This extreme heat was accompanied by widespread fires across London and elsewhere in England, which destroyed houses and prompted evacuations. While attribution studies have identified a strong human fingerprint contributing to the heatwave, no studies have attributed the associated fires to anthropogenic influence. In this study, we assess the contribution of human-induced climate change to fire weather conditions over the summer of 2022 using simulations from the HadGEM3-A model with and without anthropogenic emissions, and apply the Canadian Fire Weather Index. Our analysis reveals at least a 6-fold increase in the probability of very high fire weather in the UK due to human influence, most of which is driven by high fire conditions across England. These findings highlight the significant role of human-induced climate change in the emerging threat of wildfires in the UK. As we experience more hotter and drier summers as temperatures continue to rise, the frequency and severity of fires are likely to increase, posing significant risks to both natural ecosystems and human populations. This study underscores the need for further research to quantify the changing fire risk due to our changing climate, and the urgent requirement for mitigation and adaptation efforts to address the growing wildfire threat in the UK.

Introduction

The UK experienced an unprecedented heatwave in the northern hemisphere summer of 2022, when maximum temperatures reached 40°C for the first time in recorded history. This resulted from a high pressure system that developed across western Europe, drawing hot air northward and saw severe heatwave conditions and wildfires develop across the region, with July maximum temperature records also broken in Portugal, France and Ireland[1]. This notable climatological event was characterized by exceptional temperatures, prolonged dry conditions, and widespread wildfires. On 19th July 2022, a maximum temperature of 40.3°C was recorded at Coningsby, closely followed by 40.2°C in St. James's Park in London and 40.1°C in Nottinghamshire (Kendon 2022). A remarkable feature of the event was how widespread the extreme temperatures were, with seven official weather stations exceeding 40 °C, and temperatures exceeding 39°C as far north as North Yorkshire. New record high daily maximum temperatures were also recorded in Wales (37.1°C in Hawarden, Flintshire) and Scotland (34.8°C in Charterhall, Scottish Borders)[2]. Concurrently, fires broke out across London and elsewhere in England, including the Wennington grassland fire in East London that destroyed 20 houses. This was one of 24,316 wildfires across England between June and August, a four-fold increase on the same period in the previous year[3,4]. The London Fire Brigade were reported to have said that this was their "busiest day since World War 2" (BBC News, 2022[5])

This event occurred in the context of observed warming of the UK climate, and drying of summers, both of which are projected to become more severe with ongoing anthropogenic climate change even in low emissions scenarios that meet the goals of the Paris Agreement (UKCP18). By the end of the 21st Century all areas of the UK are projected to be warmer, with hot summers becoming more common. Hot spells (defined as two consecutive days above 30°C) could occur around 4 times per year by the 2070s under a high emissions scenario. Kendon et al (2024) show that observed changes in extremely hot days have increased at a much greater rate than average temperatures, with days above 30°C or 32°C more than trebling in the most recent decade compared to a 1961-1990 baseline. The UK climate projections (UKCP) also indicate an overall summer drying trend (Met Office 2022). Analysis conducted for the 3rd UK Climate Change Risk Assessment highlighted wildfire as an emergent risk to the UK, with a number of impacts and cascading risks potentially affecting many sectors (Belcher et al 2021, Betts et al 2021).

A rapid attribution study by the World Weather Attribution (Zachariah et al 2022) found that the 2022 heatwaves resulted in at least 13 deaths, was extremely unlikely to have occurred

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[1] https://climate.copernicus.eu/surface-air-temperature-july-2022, last accessed 05/08/2024

[2] https://www.metoffice.gov.uk/about-us/press-office/news/weather-and-climate/2022/record-high-temperatures-verified, last accessed 05/08/2024

[3] https://nationalemergenciestrust.org.uk/wildfires-growing-risk/, last accessed 05/08/2024

[4] https://www.forestryjournal.co.uk/news/23236807.firefighters-tackled-nearly-25-000-wildfires-summer-2022/, last accessed 05/08/2024

[5] https://www.bbc.co.uk/news/uk-england-london-62236018, last accessed 05/08/2024

without anthropogenic climate change, and that human-caused climate change made the event at least 10 times more likely. A previous study by Christidis et al. (2020) had also investigated the likelihood of exceeding 40 ˚C in the UK, and likewise reported it to be extremely unlikely without climate change and around 10 times more likely in the current climate, and becoming as frequent as every 3-4 years by the end of century under a high emissions scenario. However, to date, there has not been an attribution study of the contribution of climate change to the likelihood of increased wildfires over this period.

Attributing wildfires to human or natural causes is more complicated than other extreme events because multiple contributing factors drive fires. These can be split into meteorological, biological, physical, and social. The meteorological and biological aspects that affect flammability include fire weather (temperature, precipitation, relative humidity, wind), ignition (lightning), fuel (leaves, litter, trees, grasses, bark, twigs, shrubs, peat), and fuel dryness (soil moisture, fuel moisture). Topography (slope, elevation and aspect) and wind can affect the spread of a fire. Social components include direct ignition (accidental or deliberate), suppression, and land-use change which affects fuel availability.

A common approach to attributing wildfires, therefore, is either to attribute separate drivers, such as temperature (Gillett et al 2004), fuel moisture (Williams et al 2019), Vapour Pressure Deficit (Tett et al 2018) or human land use (Kelley et al. 2021) as proxies, or to use a fire weather index to understand how climate change has altered the likelihood of weather conditions that sustain fires once they are ignited.

Here we use the well-established Fire Weather Index (FWI) to assess the contribution of anthropogenic climate change to the 2022 UK wildfires. We first outline the attribution methodology utilised in this study, then present the results of our attribution analysis, highlighting the influence of anthropogenic climate change on the observed extremes. Finally we discusses the broader implications of our findings, and summarise the key findings from this study.

Methods

For this study we use the FWI, initially developed for operational use by the Canadian Forest Service as part of the Canadian Forest Fire Danger Rating System (Wagner 1987). The FWI is used in multiple operational contexts, including the European Forest Fire Information System (EFFIS[6]), the Global Wildfire Information System (GWIS[7]), and the Canadian Wildland Fire Information System (CWFIS[8]), and as the basis for the Met Office Fire Severity Index[9] (Perry et al 2022). The FWI has also been frequently used in attribution studies including (Li et al 2021); (Du et al 2021); (Goss et al 2020); (Jan Van Oldenborgh et al 2021); (Kirchmeier-Young et al 2017, 2019); (Touma et al 2021); (Abatzoglou and Williams 2016); (Barbero et al 2020);

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[6] https://forest-fire.emergency.copernicus.eu/, last accessed 02/06/2024

[7] https://gwis.jrc.ec.europa.eu/, last accessed 02/06/2024

[8] http://cwfis.cfs.nrcan.gc.ca/, last accessed 02/06/2024

[9] https://www.metoffice.gov.uk/public/weather/fire-severity-index/#?tab=map&fcTime=1711281600&zoom=5&lon=-4.00&lat=55.74, last accessed 05/08/2024

(Krikken et al 2021), as well as the World Weather Attribution study of the Canadian wildfires in 2023 (Barnes et al 2023). More recently it was used by Jones et al (2024) in the State of Wildfires 2023-24 report.

The FWI is calculated using several drought indices, including the Build Up Index and Initial Spread Index, which combine to produce the Fine Fuel Moisture Code, the Duff Moisture Code and the Drought Code (Wagner 1987). To calculate the index, we use two-day average precipitation and daily maximum temperature (as a proxy for noon values, as per Perry et al (2022)), daily mean wind speed, and daily mean relative humidity.

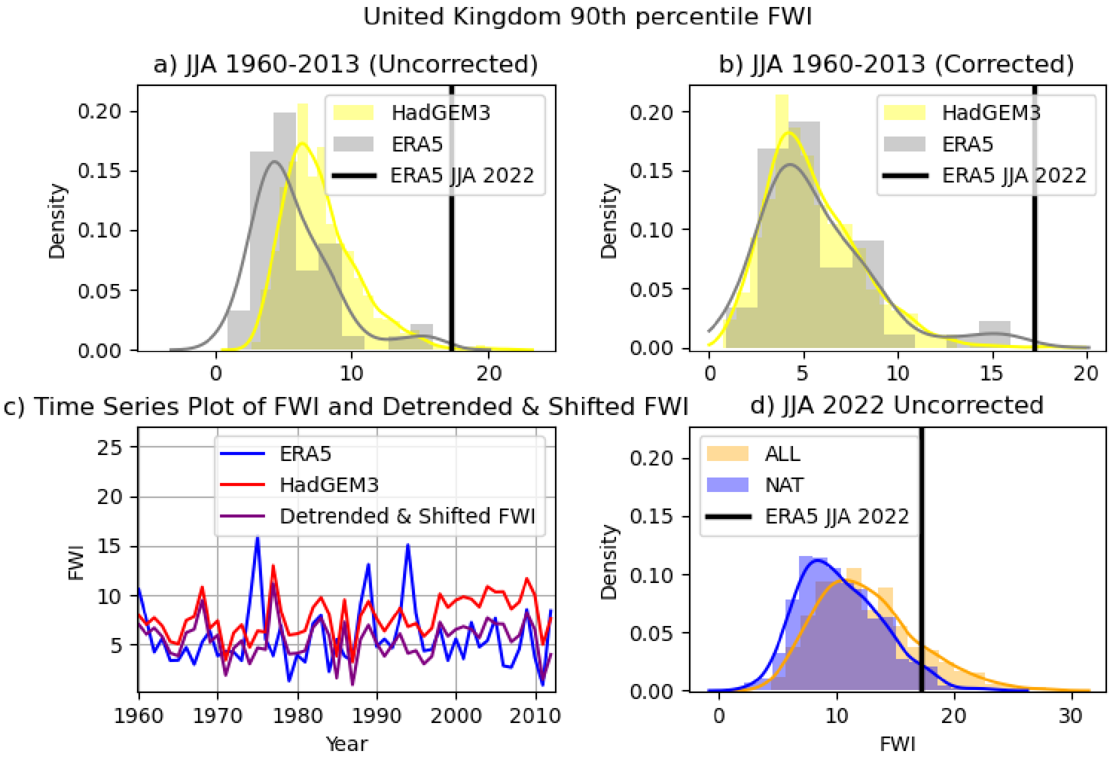
For the attribution analysis, we use the large ensemble simulations from HadGEM3-A (Ciavarella et al 2018). This atmosphere-only model uses observed sea surface temperatures (SSTs) and sea ice boundary conditions, producing ensemble statistics that retain a degree of ocean influence; for example, near-surface air temperatures can correlate significantly with observations. Therefore, we can see the ensemble as exploring a wide range of climate variability conditional on the boundary conditions. A limitation is that this approach only uses a single model, so will not capture the diversity of climate and model uncertainty from a multi-model ensemble.

For the historical validation of the model, we use the 15-member HadGEM3-A ensemble (hereafter HadGEM3) to calculate the FWI and compare this to the FWI calculated using ERA5 reanalysis data (C3S, 2024) which we refer to as the ‘observed FWI’, over JJA for the period 1960-2013 (Figure 1). The 0.25-degree resolution observed FWI was regridded by linear interpolation to match the 0.5-degree model grid. For the 2022 attribution analysis, we use two sets of large ensembles, with 525 members of historical forcing (with natural and anthropogenic forcing present), and 525 members of natural-only forcing (solar irradiance and volcanic activity only). The historical simulations (ALL) include historical emissions of well-mixed greenhouse gases, aerosols, and transient land use change, which are all held constant at 1850 levels in the natural-only simulation (NAT). An estimate of the changes in SSTs and sea ice fields due to anthropogenic influence, based on results from phase 5 of the Coupled Model Intercomparison Project (CMIP5), is removed in NAT (Christidis et al 2013). Specifically, the anthropogenic influence in SSTs is taken from the difference between multi-model means of the ALL and NAT experiments, while the change in sea ice fields is derived from a linear relationship between observed SST and sea ice. We use ERA5 reanalysis data to calculate the FWI over JJA 2022, giving the observed fire severity across the UK for the period and the probability of exceedance in the ALL and NAT simulations.

Our analysis focuses on the 90th percentile of FWI over the UK during June, July, and August (JJA).

Bias correction

To validate the model, we calculate 90^{th} percentile of FWI over the historical period JJA 1960-2013 using ERA5 reanalysis data and compare the distribution to the FWI calculated for the same period and percentile with the 15 member HadGEM3 data. For the UK, the modelled FWI has a positive bias compared to ERA5 (Figure 1a). Given this model bias compared to ERA5, we apply a bias correction to ensure the event threshold for 2022 lies at the same percentile in the model distribution as the ERA5 distribution. After evaluating the individual variables in the FWI, we found that each variable is slightly biased compared to ERA5 (Figure S1, and we therefore apply a bias correction to the final FWI, as per Jones et al (2024), rather than bias-correcting each variable individually. We compare the time series and distribution of the modelled and observed FWI, and apply a simple linear regression to find the bias correction required for the 2022 model output. The correction adjusts the trend and absolute value while maintaining variability, and the model successfully reproduces the observed distribution after applying the correction (Figures 1b and c; Figures S3-6). For reference, the distribution for 2022 before bias correction is also shown (Figure 1d), and the range of the ensemble time series is shown in Figure S2.


United Kingdom 90th percentile FWI

a) JJA 1960-2013 (Uncorrected)

b) JJA 1960-2013 (Corrected)

c) Time Series Plot of FWI and Detrended & Shifted FWI

d) JJA 2022 Uncorrected

Figure 1: Bias correction for the UK. Historical ensemble of HadGEM3 (yellow) compared to ERA5 (grey) 90th percentile of FWI for the historical period (JJA 1960-2013), shown as probability density before correction (a) and after correction (b), and one member shown as a time series (c, where HadGEM3 is shown in red, ERA5 in blue and adjusted HadGEM3 in purple). HadGEM3 ensemble for 2022 shown before bias correction (d). ERA5 2022 event is shown as a black vertical line on all probability density plots.

We bias-corrected the HadGEM3 2022 large ensemble based on a bias assessment of the 15 historical members from 1960-2013 vs. ERA5 observation-driven FWI, using a linear regression on *fwi* transformed using:

$$fwi_* = log(exp(fwi) - 1) \tag{1}$$

to remove the physical bound at 0. We use this instead of a straight log transformation as it ensures numerical stability at higher values, which is crucial when dealing with extreme FWI values. It also preserves the extreme tail of the FWI distribution, allowing us to accurately capture and analyse critical events associated with high fire risk.

We perform a linear regression on ERA5 and on each historical member to obtain the basic regression parameters:

$$fwi_{*} \sim fwi_{*,0} + \Delta_{fwi} \times t \qquad (2)$$

Where t is time, and t = 0 is set to 2022, Δ_{fwi} is the rate of change, or trend, of fwi_{*} and $fwi_{*,0}$ is the estimated $fwi_{*}$for 2022. Our bias correction is based on present-day warming levels, considering the additional warming from 2013-2022 (assuming the trend from 1960-2013 continues to 2022 linearly). This is likely conservative, given that warming rates may have increased rapidly in the last 10 years.

Similar to the method presented in Christidis et al (2020), we generate the bias-corrected 2022 ensemble by correcting each of the 525 present-day ensemble members against each of the 15 historical members (creating an ensemble of 7875 members) and iterate over all possible pairs:

$$fwi_{corrected} = (fwi_{*i} - fwi_{*0,j}) \times \sigma(fwi_{*era5}) / \sigma(fwi_{*j}) + fwi_{0,*\,era5} \qquad (3)$$

$$\sigma_{\Delta}(fwi_{*}) = sdev(fwi_{*} - \Delta_{fwi} \times t)$$

Where i is a present-day ensemble member, and j is a historical member.

We finish by applying the inverse of the transformation from Equation 1 :

$$fwi_{\,corrected} = log(exp(fwi_{*,corrected}) + 1) \qquad (4)$$

Probability ratio

We use the ERA5 2022 FWI for our event threshold in each region on our bias-corrected ensemble. We use this threshold to calculate the probability ratio (PR) of the event occurring with and without climate change. To calculate the PR, we find the number of ensemble members that exceed the 2022 ERA5 90th percentile FWI value in the bias-corrected ALL simulation and divide this by the number of members that exceed the same value in the bias-corrected NAT simulation (equation 5), randomly sampling 90% of the data without replacement 10,000 times to give the probability of exceeding the observed 2022 FWI value in a world with and without climate change plus uncertainty bounds for the 5-95th percentile.

$$PR = p(ALL) / p(NAT) \qquad (5)$$

The return time is calculated as the inverse of the probability of exceedance, also bootstrapped 10,000 times:

$$RT = 1 / p(ALL) \qquad (6)$$

Results

Following the historical validation of the model against ERA5, we calculate the 90th percentile of FWI for JJA 2022 in HadGEM3, apply the bias correction (see Methods and Figure 1), and compare the probability distribution of the all-forcing simulations (ALL) to the natural-only forcing simulations (NAT). For the UK, there is a clear shift to higher FWI values in the ALL forcing simulations, and more of the distribution lies at higher FWI values compared to NAT (Figure 2). The threshold of the 90th percentile of FWI in the JJA 2022 ERA5 data, marked with a vertical black line in Figure 2, falls within the 'very high' category of FWI (Table S1; Table S2). We find a greater proportion of the distribution exceeding this value in ALL compared to NAT, and therefore a higher probability of experiencing very high fire weather such as seen during JJA 2022 in a climate modified by human influence.

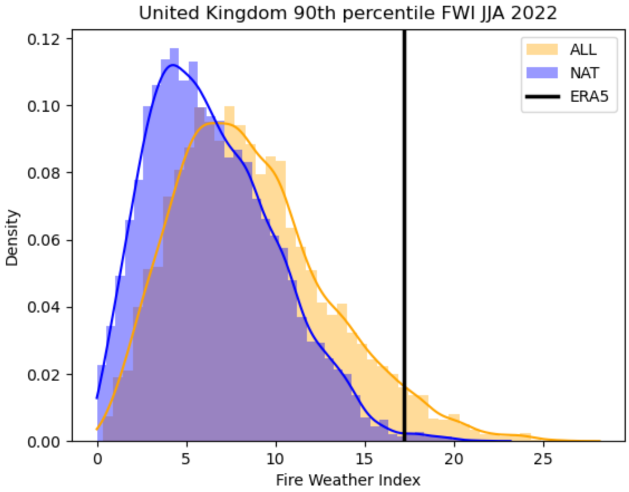


Figure 2: Distribution of 90th percentile of FWI for the UK JJA 2022 in ALL (ORANGE), NAT (BLUE) and ERA5 event threshold (black line)

When examining the variations in FWI across the different regions of the UK, our analysis reveals a notable increase in the probability of elevated FWI across all areas, attributable to anthropogenic climate change (Figure S7). Notably, England exhibits the highest FWI values, significantly contributing to the overall heightened FWI levels observed throughout the UK (Figure 3, Figure S7). Calculating the probability ratio for each UK country, we find that Wales experiences the most significant increase in the probability of high-fire weather due to anthropogenic climate change, with an 8.9 to 15.4-fold increase (Figure 3; Table S1). This means Wales is up to 16 times more likely to experience high-fire weather because of human emissions. England follows with a 6.3 to 10.5-fold rise, while Scotland shows a 5.0 to 11.4-fold increase, and Northern Ireland sees a more modest elevation of 3.3 to 4.1. The UK as a whole faces an overall increase of 6.2 to 11.2. While the PR increases the most for Wales, the absolute FWI is lower than in England, and therefore an increased probability of high fire weather has a disproportionate impact on England, the primary driver of the nation's increased fire weather risk.

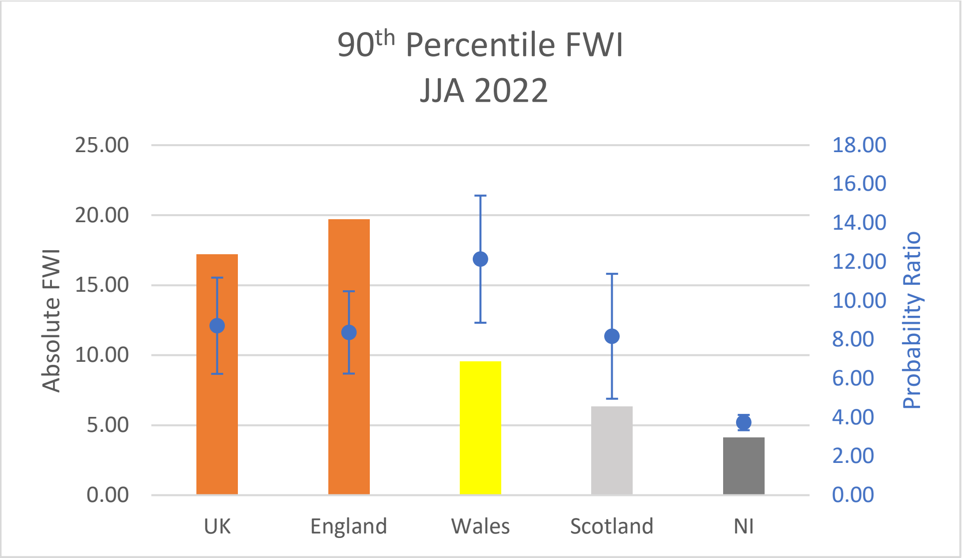


Figure 3: Absolute observed FWI from ERA5 (bars, left axis), and probability ratio (point and whiskers, right axis) for increase in 90th percentile of FWI due to climate change for the UK and individual countries (NI = Northern Ireland). The colours used for the bars relate to the FWI category (see Table S2); low (dark grey); moderate (light grey); high (yellow), very high (orange). The PR range bars indicate the 5th – 95th percentiles across the ensemble of probabilities, with the point showing the central value of this range.

The return times in each region are much lower in the ALL simulations compared to NAT. For example, the median return time for the 90th percentile of FWI in the UK is 24 years with all forcing compared to 192 years with natural only forcing. For England, the return times are similar, at 19 and 154 years, meaning we can expect to see very high fire weather occurring roughly every 20 years in a climate warmed by anthropogenic emissions, compared to 150-200 years in a climate without human influence. Northern Ireland's return times are lower overall, at 7 and 25 years. In contrast, Scotland's is much higher at 53 and 375 years, and the extreme values here extend to over 1000 years, illustrating an extremely low likelihood of high fire weather occurrence under natural conditions.

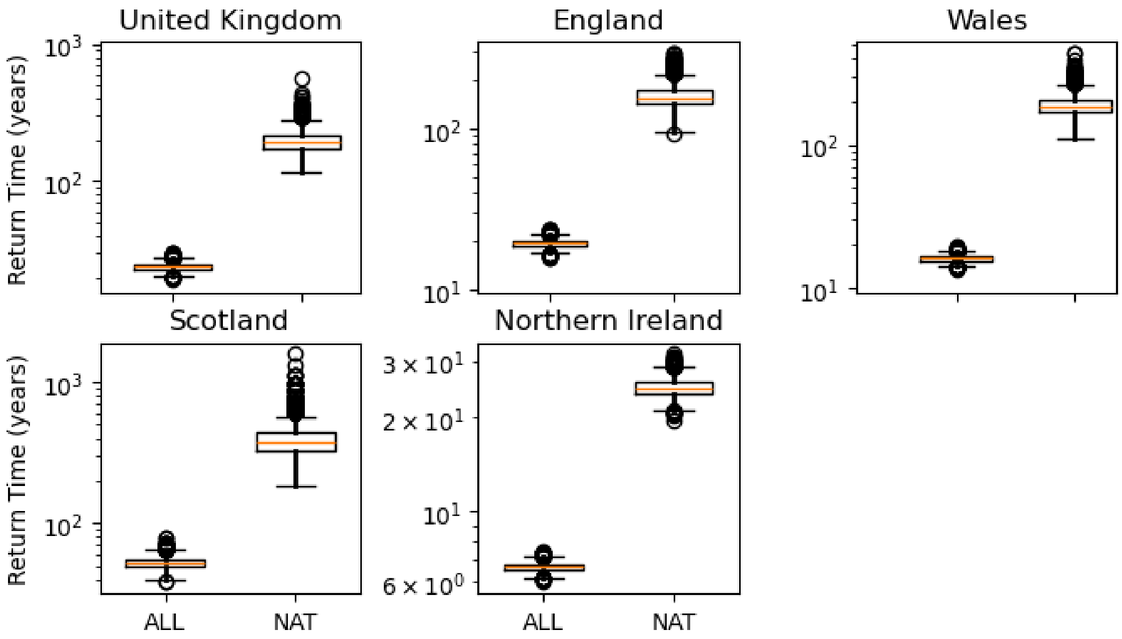


Figure 4: Return times for 90th percentile of FWI in ALL and NAT for UK and individual countries (using log scale). The box represents the median (red line) and interquartile range (box), with whiskers extending to the farthest data point lying within 1.5x the inter-quartile range from the box. Flier points are those past the end of the whiskers.

Discussion

Historically, large wildfires fires have not played a significant role in shaping the ecosystems of the United Kingdom, although the use of fire by humans for landscape management has been common practice for centuries (Belcher et al 2021). The region's temperate and often wet climate has typically suppressed large-scale fire outbreaks. However, recent years have seen a marked increase in fire occurrences across the UK, particularly on moorlands, which has presented new challenges for land management and fire suppression efforts. These fires are becoming more frequent, larger and more intense, driven by increasingly favourable fire weather conditions characterised by hotter and drier summers.

Notable incidents such as the 2019 Marsden Moor fire in Yorkshire, which burned 700 hectares and took four days to extinguish[10], underscore the growing severity of these events. Similarly, the 2018 Saddleworth Moor fire in Greater Manchester, which necessitated the evacuation of 50 homes and scorched seven square miles, remains one of the largest fires in recent memory. The 2020 fires on Darwen Moor and in Wareham Forest which burned areas of 500 hectares[11] and 200 hectares[12] respectively, resulting from human ignitions (i.e.

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[10] https://www.nationaltrust.org.uk/visit/yorkshire/marsden-moor/our-work-to-protect-marsden-moor-from-fires, last accessed 05/08/2024

[11] https://www.lancsfirerescue.org.uk/news-and-events/wrapped-fire-engines-added-to-lancashire-fleet, last accessed 05/08/2024

[12] https://www.bbc.co.uk/news/uk-england-dorset-58479215, last accessed 05/08/2024

through disposable BBQs) further exemplifies the increasing frequency of large fires occurring as a result of human ignitions. October 2021 saw over 100 moorland fires reported within four days, a five-fold increase from the previous year[13]. The Sutherland peatland fire in Scotland lasted for six days in 2019, impacting over 5,300 hectares and releasing between 174 and 294 kilotons of Carbon—twice Scotland's carbon emissions during that period[14]. These trends highlight a troubling escalation in fire activity that poses significant risks to both natural and human systems.

The implications of these fires are particularly concerning given the ecological and conservation significance of the UK's moorlands. Many of these areas, such as Marsden Moor, are designated as Sites of Special Scientific Interest, Areas of Outstanding Natural Beauty, and crucial conservation sites. Moorlands are also important carbon sinks, storing large amounts of peat and carbon. When these areas burn, numerous species' habitats are disrupted, and substantial amounts of carbon are released into the atmosphere, exacerbating global warming. Additionally, the fires contribute to dangerous air quality, which has direct adverse effects on human health (Forestry Commission 2023).

Urban areas are not immune to these trends, as demonstrated by the major fire incidents in London and Norfolk in 2022, which damaged infrastructure and posed significant risks to lives and livelihoods. In the UK, a significant number of fires ignite at the interface between rural and urban areas (Perry et al 2022). For example, between 2009/10 and 2020/21 the UK Fire and Rescue Services dealt with over 360,000 wildfires in England, with 54.4% of these occurring in urban and garden areas (Forestry Commission 2022). With analysis in this study revealing that England is driving high FWI in the UK, it is concerning in terms of risk that England's population density is approximately four times that of Scotland and three times greater than Wales (Office for National Statistics (ONS) 2024). Higher population density not only increases the potential risk to life but also contributes to increased fire frequency due to more potential ignition sources. Although England may experience a smaller burned area per year on average compared to Scotland for example[15] the higher fire weather danger could significantly increase the risk to human life due to the greater likelihood of fires occurring in the urban environment.

With climate change, fires will become more significant in the UK (Perry et al 2022), with potentially profound implications for impacts and risks across many sectors (Betts et al 2021, Belcher et al 2021) necessitating a proactive approach to managing this evolving threat. This underscores the broader societal impacts of an increasing fire risk in the UK. To mitigate the risk of wildfires in susceptible environments, several strategies can be employed. Engagement with the public in the form of public awareness campaigns can re-educate on fire safety measures, emphasising the importance of safe outdoor cooking practices and

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[13] https://www.theguardian.com/environment/2021/oct/12/moorland-fires-reported-in-england-carbon-dioxide, last accessed 05/08/2024

[14] https://www.copernicus.eu/en/media/image-day-gallery/peatland-wildfire-sutherland-scotland-uk, last accessed 05/08/2024

[15] https://www.gov.scot/publications/provision-analyses-scottish-fire-rescue-service-sfrs-incident-reporting-system-irs-data-relation-wildfire-incidents/pages/8/, last accessed 05/08/2024

vigilance reporting activities that could result in an ignition. Engagement between international collaborators is especially important for nations like the UK, which historically have not experienced large wildfire incidents and thus possess limited experience in this domain. Engaging with global partners and proactively establishing measures to prepare for and mitigate the risks of wildfires is crucial to prepare for increasing fire risk in the future (Hamilton et al 2024).

Conclusion

In this work we have explored the 2022 UK high-fire weather experienced during the JJA heatwave in the context of climate change. Using a large attribution ensemble, we found that FWI was higher in a world warmed by anthropogenic climate change than in a world with natural-only forcing for the UK and each UK country. Overall, anthropogenic forcing has increased the likelihood of experiencing high fire weather conditions more than 6-fold. This indicates that human influence likely contributed to the high-fire weather experienced across the UK in JJA 2022.

The recent upsurge in fire incidents across the UK marks a significant departure from historical trends and signals a critical shift in the region's environmental challenges. The examples of Marsden Moor, Saddleworth Moor, and the London fires of 2022 highlight the growing destructive nature, intensity and frequency of fires driven by hotter and drier summer conditions as the climate changes. This trend suggests that fires are becoming an increasingly important factor in the UK's ecological and socio-economic landscape.

As the UK is already seeing hotter and drier summers and faces the prospect of ongoing trends even in the lowest emissions scenarios, fires are becoming an emerging threat. This study has shown that climate change increased the likelihood of experiencing very high fire weather conditions in 2022, giving an indication of what we might see moving forward. The contribution of climate change to high fire weather conditions means that when fires do ignite, they have the potential to be larger, more intense, and harder to manage. It is imperative to develop and implement effective fire prevention and mitigation measures. The experiences of recent years serve as a stark reminder of the urgent need to adapt to a changing climate and its associated risks, and mitigate further warming through reducing our carbon emissions.

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Code and Data availability

Code and figures for the analysis in this paper can be found at: DOI: 10.5281/zenodo.13224259. The historical (1960-2013) HadGEM3 data are available through CEDA (Dataset Collection Record: EUCLEIA: European Climate and weather Events:

Interpretation and Attribution (ceda.ac.uk)). The 2022 data are available on request from the Met Office.

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Supplementary Materials

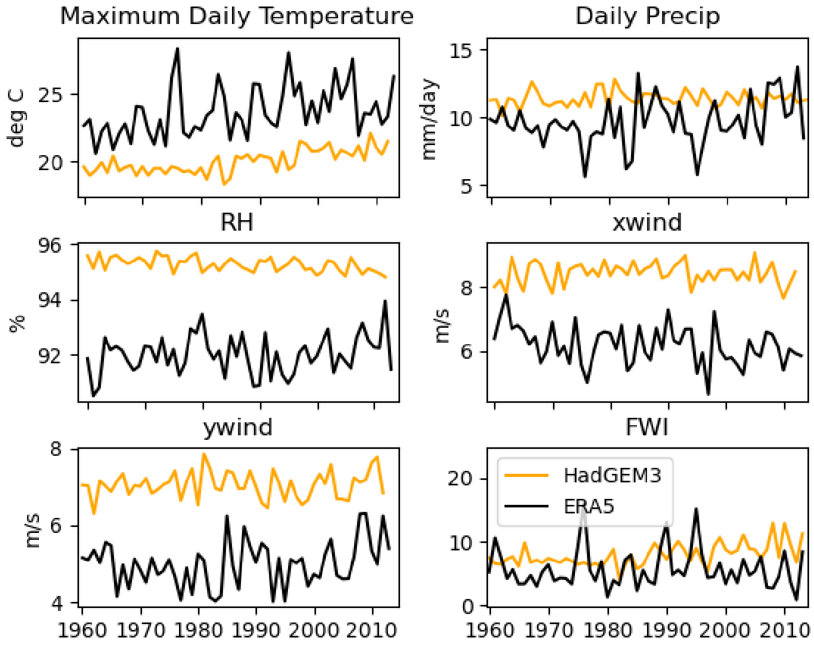

Figure S1: Time series of individual variables that make up the Fire Weather Index, and FWI. Data shown is for ERA5 reanalysis (black) and the mean of 4 ensemble members from HadGEM3 (yellow), for 90th percentile of JJA for the UK, 1960-2013

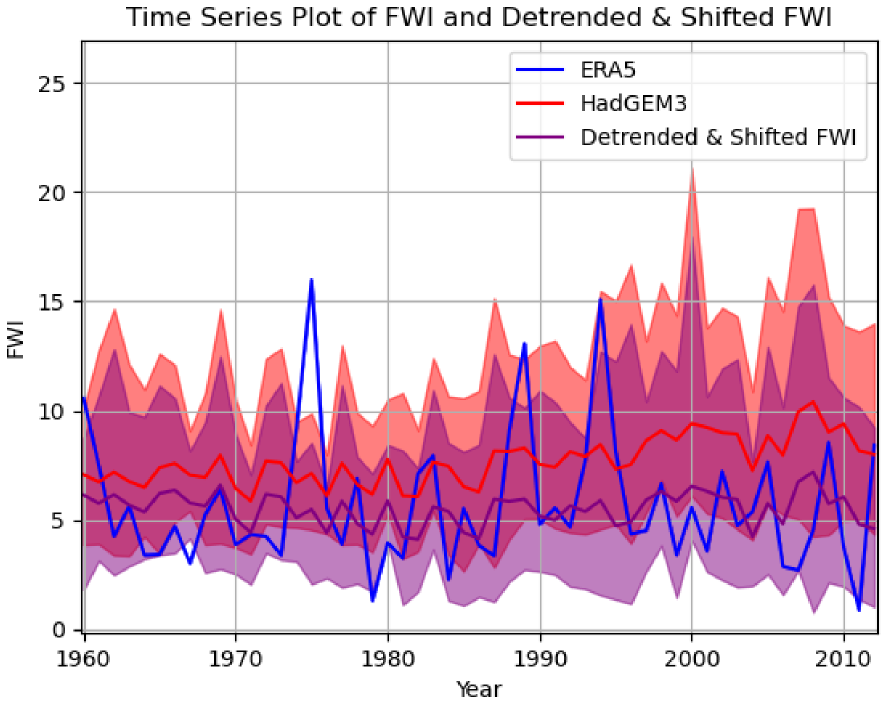

Figure S2: As for Figure 1, but showing the whole ensemble range for HadGEM3 and bias-corrected HadGEM3, with the mean shown in solid lines

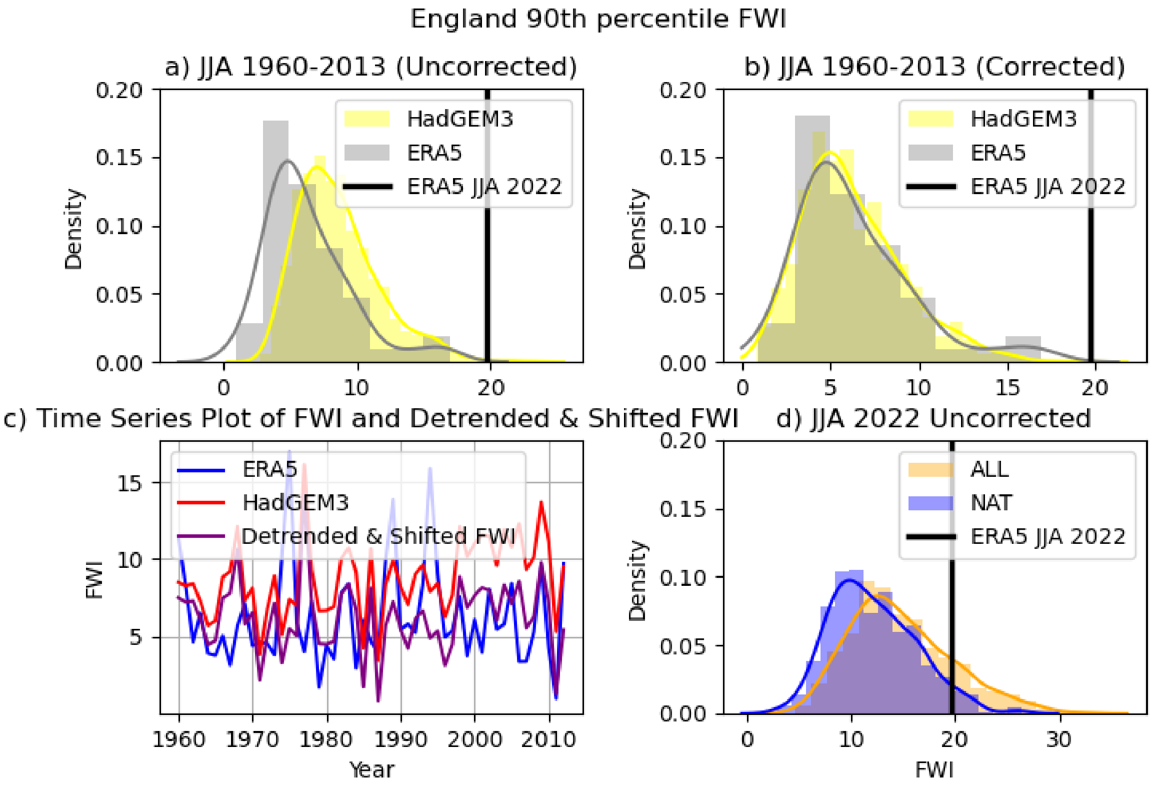

Figure S3: As for Figure 1, but for England

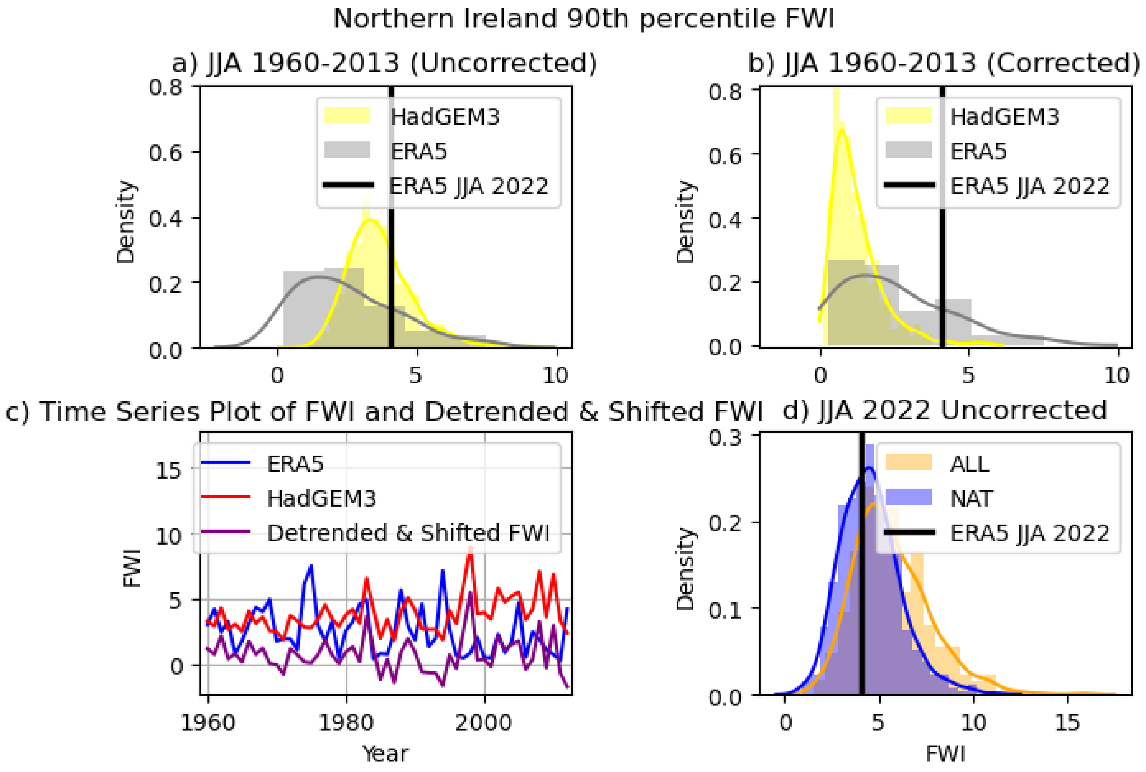

Figure S4: As for Figure 1, but for Northern Ireland

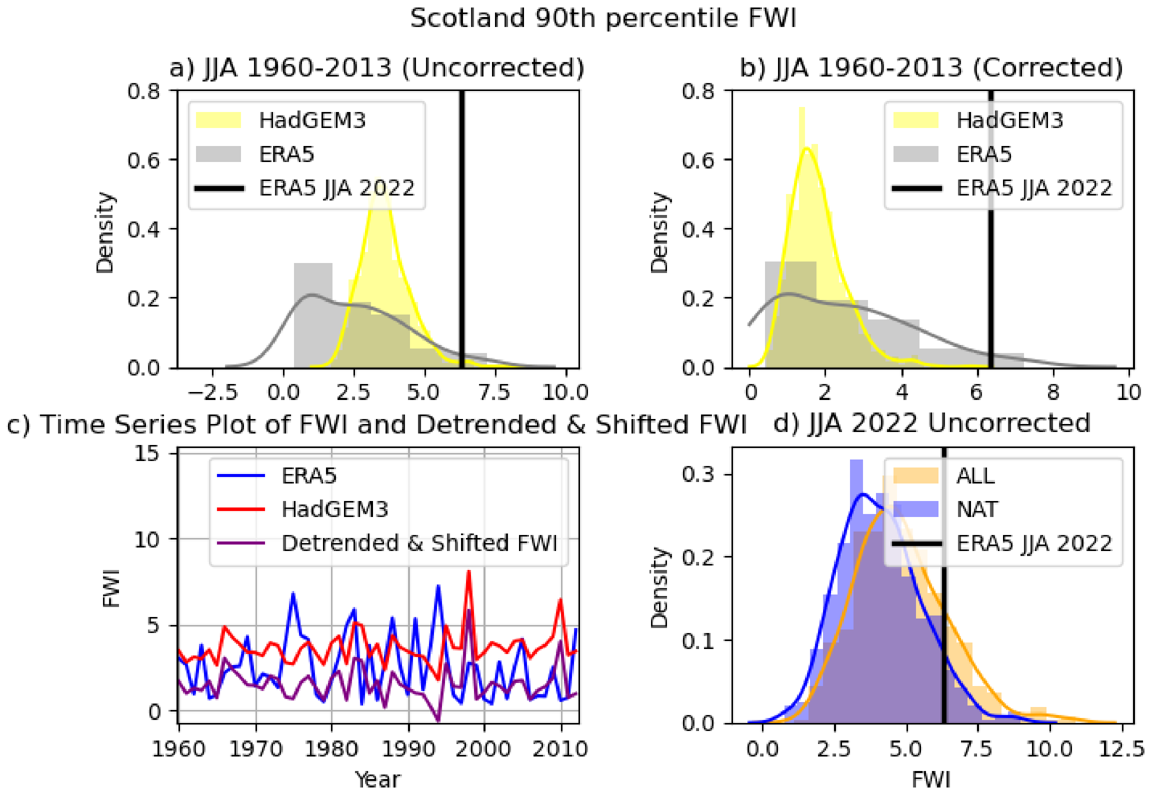

Figure S5: As for Figure 1, but for Scotland

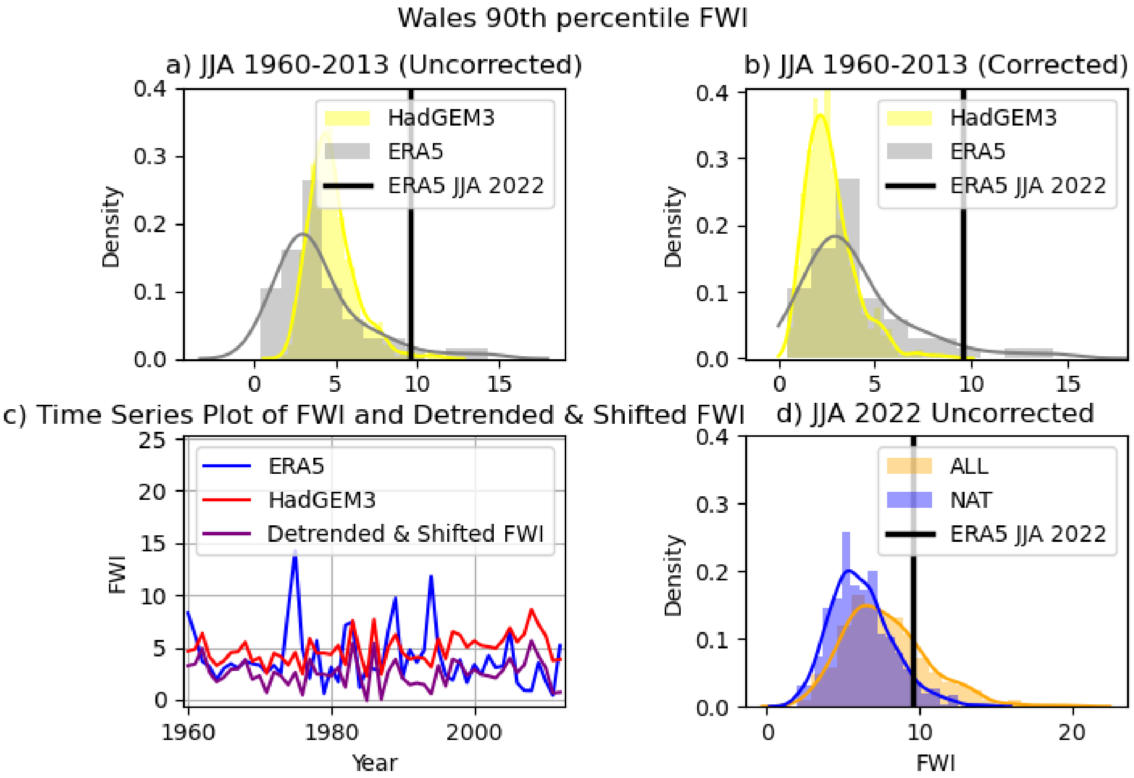

Figure S6: As for Figure 1, but for Wales

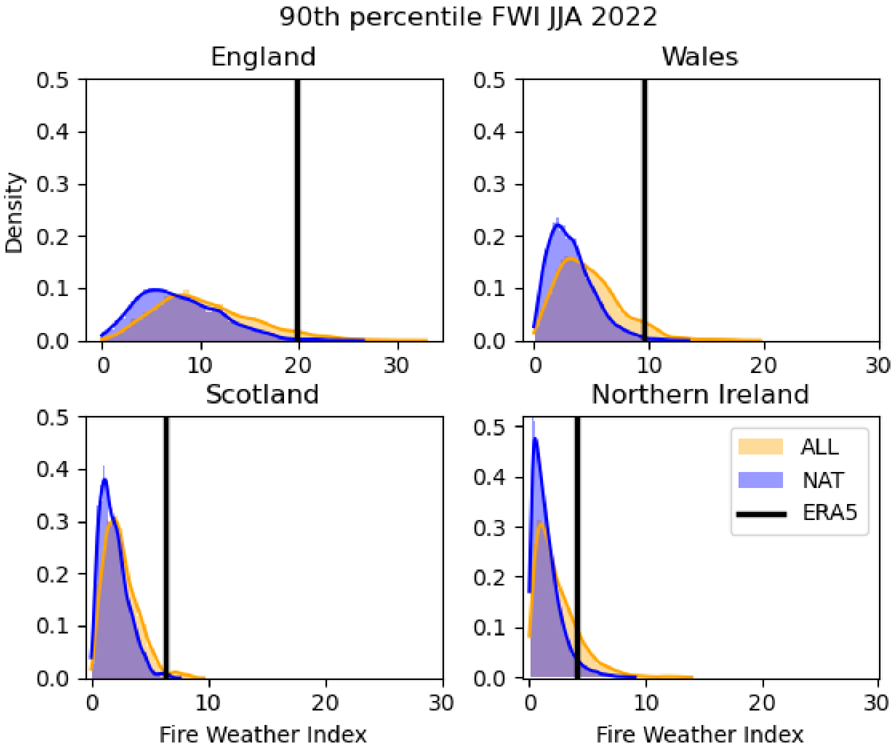

Figure S7: As for Figure 2 but for each country within the UK

Table S1: Data presented in Figure 3 (absolute FWI calculated using ERA5 data, and probability ratio calculated using model data for the UK and individual countries)

	UK	England	Wales	Scotland	Northern Ireland
Absolute FWI (ERA5)	17.22	19.72	9.57	6.33	4.11
Probability ratio (5th percentile)	6.24	6.25	8.87	4.96	3.34
Probability ratio (central value)	8.71	8.37	12.14	8.17	3.74
Probability ratio (95th percentile)	11.19	10.49	15.41	11.38	4.13

Table S2: FWI levels of fire danger

Level 1	<5	Low fire severity
Level 2	5 - 9	Moderate fire severity
Level 3	9 - 17	High fire severity
Level 4	17- 52	Very high fire severity
Level 5	> 52	Exceptional fire severity

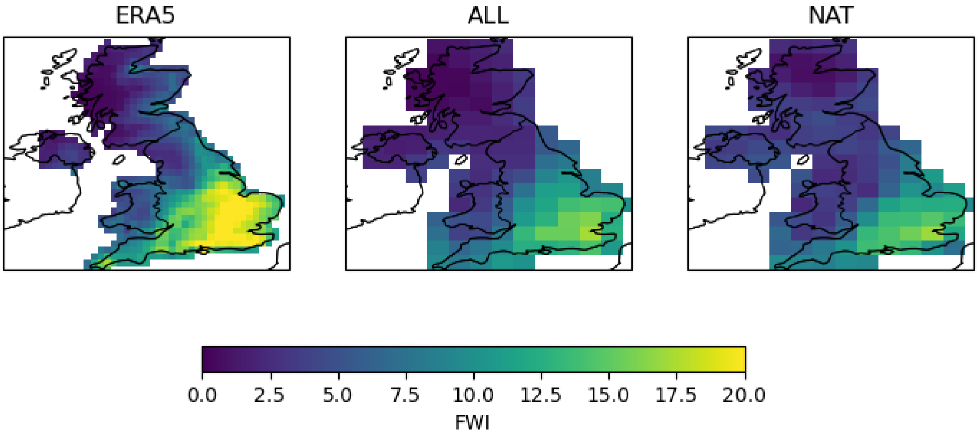

Figure S8: UK Maps for ERA5, ALL and NAT, 90th percentile JJA 2022