Dear Reviewer,

Thank you for your positive review, and for the helpful corrections – which we have implemented throughout the paper.

Best wishes,
Theodore Keeping

The manuscript addresses an important and timely topic and provides a broad regional analysis of the 2025 European wildfire season. The combination of fire-weather attribution, vegetation trends, and land-use change is valuable. However, some sections would benefit from clearer wording, reduced repetition, and smoother explanation of the research gap and methodological logic. In several places, the text is scientifically meaningful but syntactically heavy, which may reduce readability for a broad NHESS audience. I consider the manuscript suitable for publication after revision.

Line 25 – The phrase "drier summer summers" appears to contain a repetition/typo. Please revise.

> Revision made.

Introduction / early framing

Some sentences in the introduction are very long and contain several ideas at once. Consider splitting them to improve readability, especially where fire weather attribution, vegetation trends, and land-use analysis are introduced together.

Line 36 – Remove extra space after "was ".

> This and all repeated spaces were removed.

Line 42 – Maybe better not to start the sentence with 2025; for example, "The European wildfire season also recorded..."

> Changed to: "The year 2025, "

Line 44 – This sentence provides useful impact context, but smoke is not a central component of the study. Consider shortening it or linking it more clearly to the motivation for studying extreme wildfire seasons.

> This opening paragraph details the impacts of the wildfires, with a fuller explanation for the justification of the study coming towards the end of the introduction. We have tightened this sentence, having a shorter sentence explaining that smoke is a key impact of wildfires, followed by a sentence summarising the top line on emissions and air quality:

“Wildfire smoke broadens the otherwise localised impacts of wildfire events, resulting in major health and mortality impacts globally (Naeher et al., 2006; Johnston et al., 2012; Chen et al., 2021). The year 2025 had the highest European wildfire emissions since 2003 when the full global MODIS record began, leading to worsened air quality in Portugal and Spain (Parrington and McNorton, 2025).”

Line 51–54 – This sentence is conceptually important but difficult to follow. Consider simplifying the structure after “allows” and clarifying that the study assesses how changing wildfire drivers contribute to the severity of extreme wildfire seasons.

We have split up and clarified this:

“This paper offers a detailed description of the driving conditions of 2025’s extreme wildfire events, coupled with attribution of fire weather conditions and trend analysis of land-use and vegetation. This allows the contribution of multiple rapidly changing wildfire drivers to extreme wildfire seasons to be assessed in detail, providing insight into the present and future state of the European wildfire hazard.”

Lines 117, 188, 218, 222, and 238–246 – Several regional background statements would benefit from stronger citation support.

Line 117: This sentence was removed following feedback from reviewer 1.

Line 188: The statements about burned area and fire weather are substantiated above, the statement on suppression capacity is substantiated by Sánchez-Hernández et al. (2025), which has been added to the end of the sentence.

Line 218, changed to: “Western Greece and the Ionian islands north of the Peloponnese peninsula are less fire-prone than southern and eastern Greece (Kalabokidis et al., 2024), due to generally less extreme fire weather.”

Line 222, changed to: “Wildfires are primarily human-caused, and typically occur in mosaic shrubland and pine forest ecosystems (Kalabokidis et al., 2024).”

Line 238–246, changed to: “The wildfire regime of northwestern Türkiye is a transitional dual system, with the historically humid, low-frequency regime of the Euro-Siberian Black Sea forests increasingly replaced by the frequent, high-intensity fire dynamics of the Mediterranean coast (Şahan et al., 2022; Şahan et al., 2023). The high-intensity fires peak in summer, with a late-spring also seeing a pulse of smaller, predominantly human-ignited agricultural fire use in Thrace and southern Marmara (Yakupoğlu et al., 2022). Although usually small, these agricultural fires frequently escape into forest edges – especially given a dry spell, as observed in the Bursa–Bilecik–Eskişehir fires of early summer 2025. Critical wildfire danger is understood to increase sharply under elevated temperatures, low humidity and delayed autumn precipitation. This condition is now increasingly common during summer heatwaves, as Mediterranean climate characteristics expand northward and formerly humid forests lose their buffering capacity (Ekberzade, 2026).”

Line 190 – The phrase "low, highly connected vegetation" may be vague for some readers. Consider revising to "short, continuous vegetation" or "connected surface fuels" to clarify that "low" refers to vegetation height, not low fuel amount.

Revised to "short and highly connected vegetation"

Line 255 – Please remove the repetition of "detailed" and make the research-gap explanation smoother. The contrast between the relatively strong understanding of recent regional wildfire drivers and the limited understanding of longer-term fire-regime changes due to the short satellite-based record is important, but it could be expressed more clearly.

Per a comment from the other reviewer, we have moved this paragraph to the introduction, we have clarified the explanation and extended it:

"As laid out in section 2, there is detailed knowledge of the regional drivers of extreme wildfire events across European fire regimes – with many changes in these drivers observed across environments. However, partially due to the relatively short observed, satellite-based wildfire record, the causes of historic changes in the fire regime are poorly understood – as detected fire trends are often not statistically significant over short observation periods (). Using our knowledge of the drivers of wildfire extremes, we are able to address this gap. We provide a systematic attribution study of the weather-related drivers of fire, aiming to give a detailed overview of how the likelihood of the different contributing weather conditions to extreme wildfire has changed over time. This quantification of the changing probability of realised extreme fire weather and its resulting wildfires can be a key input to expert and operational planning for future wildfire extremes across Europe. By assessing five extreme fire seasons across Europe, this research samples a high diversity of meteorological drivers of elevated fire danger (e.g. spring drought in Britain; heat and hydroclimatic whiplash in Iberia; and compound hot, dry and windy conditions in the Eastern Adriatic) across a broad range of fire-prone environments, whilst also accounting for trends in vegetation and land use. In addition to being specifically useful to understanding (1) why the 2025 fire year was so extreme in Europe and (2) how the hazard profile is changing in the five case study regions, this work is also illustrative of the spread of possible extreme fire events and their drivers across Europe and how those are likely to change in the future."

Methods section

The methodological framework is strong, but some readers may benefit from a clearer explanation of why specific variables were selected, especially HDWI, VPD, seasonal effective precipitation, LAI, and managed land fraction. A short linking paragraph could help connect these variables to the conceptual wildfire-driver framework.

To facilitate this link, we have merged sections 3.5 and 3.6, into the following combined section, with the first paragraph inserted:

“3.5 Additional Analysis of Leaf Area Index and Managed Land Fraction

This study is primarily concerned with the attribution of the meteorological drivers of fire to climate change. Whilst this could be achieved via a composite fire weather index, this would not help with disentangling (1) how different meteorological drivers combine to create different fire extremes, or (2) how these meteorological drivers are separately changing. The five meteorological indices analysed here capture both instantaneous fire weather conditions (dry heat – VPD, high winds, and a simple composite of the two – HDWI) and the key, additional roles of ecological drought (fire season effective precipitation) and growing season moisture availability (prior season effective precipitation). Whilst weather extremes drive fire extremes, without consideration of the vegetation and land management, attributed trends cannot be linked to realised fire activity. To assess these we analysed trends in LAI, as a metric of fuel availability, and the fraction managed land, as a measure of land reclamation or abandonment.

To calculate the managed land fraction, we analysed changes in cultivated versus natural lands in Europe using the HILDA+ land-cover dataset (Winkler et.al., 2021) for the years 1990 and 2019 for Europe, (-12° to 45°E, 34° to 72°N). We consider all croplands and the pastures as human managed lands, while as all forest land cover types, grass/shrubland, and sparsely vegetated are considered as natural, not cultivated lands. Then, we estimate the fraction of the area that was converted from natural to managed land, as well as the fraction of the land that was converted from managed to natural land, between years 1990 and 2019. We further extract trend in the fraction of managed land relative to natural and managed land over time since 1960, for each of five case study regions. This does not capture trends in the wildland and rural urban interfaces, which contribute strongly to both ignitions (Badia et al., 2011) and impacts (Radeloff et al., 2018) of wildfires, with the focus being on the effect of overall vegetation management intensity in a landscape.

LAI is a dimensionless measure that primarily represents the amount of living and photosynthetically active vegetation, used here as a metric for vegetation/fuel availability in a landscape. Instantaneous vegetation greenness tends to reduce wildfire occurrence and spread due to increased vegetation moisture content, whereas accumulated antecedent vegetation can increase wildfire activity due to vegetation build-up and the availability of dead biomass (Kuhn-Régnier et al., 2022). As such, mean spring (MAM) LAI can be used as a proxy for the amount of vegetation which may become available to burn during the subsequent summer season. Mean summer (JJA) LAI could act both as a potential barrier to wildfires (through live vegetation) but also as potential fuel if this vegetation were to dry out quickly. We analysed the trends in leaf area index (LAI) from two LAI products: the MODIS 500m LAI product (Myneni et al., 2021) and the corrected Seoul National University (SNU) LAI product at a 0.1° resolution (Jeong et al., 2024). The SNU LAI data was available from 1982 to 2021 and the MODIS LAI data was available from 2001-2024, providing a time-series covering the last 42 years (1982-2024) with a 20-year overlap (2001-2021). We conducted a spatial aggregation to 0.5° resolution and computed the significant pixel-wise trends in annual spring (MAM: March, April, May) and summer (JJA: June, July, August) LAI using a Mann-Kendall test and significance threshold of 0.05. The magnitude of significant trends were estimated using a Theil-Sen estimator to fit a linear slope. Spatially averaged trends were also computed for each of the study regions by taking the mean spring (MAM) and summer (JJA) LAI over the study regions and fitting a linear trend following the same trend methodology."

Discussion

The discussion is rich and well connected to the results, but some claims could be made more cautious where the evidence is indirect, especially when interpreting LAI and land-use change as proxies for fuel load, fuel continuity, or abandonment effects.

We agree that conclusions on the basis of trends in LAI and land-use should not be too bold. This was addressed in the final paragraph of the discussion, which we have expanded on to clarify this:

"Second, LAI provides a good representation of the area covered by photosynthetically active vegetation, but does not directly represent total fuel load, including dead fuels, or fine-scale vegetation continuity. Whilst a comprehensive fuel model, able to distinguish live and dead fuels, would be very useful, seasonal and total LAI in combination with moisture stress (SPEI) is sufficient to describe the basic trends in fuel moisture and abundance covered here. The trends in LAI presented in this paper give context to trends in the direct vegetation drivers of wildfire such as fuel load and continuity, but should be interpreted as indirect evidence of such shifts. Site-based studies are required for ground-truthed fuel trends. Third, the land management fraction used to describe land management here is of variable utility in different regions. It is a first-order measure of shifts in total landscape management scheme in a region, but does not account for differences in how different management schemes may result in different vulnerability to fires. For example, in the UK the great majority of forests are managed in some way, but nonetheless vulnerable to fires (e.g. Swinley Forest in 2011 or Galloway Forest Park in 2025), whilst agriculturally managed land is much less so. Whilst trends in land management should thus perhaps be ignored over Britain, in other more fire-prone regions it provides a useful heuristic for changes in land use and vegetation management."

Conclusion

The conclusion effectively summarizes the main regional contrasts, but it is quite dense. Consider shortening some sentences and emphasizing the main contribution more clearly: climate change has increased key fire-weather hazards, while vegetation and land-use changes modulate regional wildfire potential.

To improve readability, we split the concluding paragraph and broke sentences up where possible. This emphasised the main conclusion in what is now the second paragraph, detailing where there is emergence from variability in models and observations. In the conclusion we focus on the effect of climate change on key fire-weather hazards, with the modulation of vegetation and land-use treated as additional context but not as highly weighted analysis. This is also in alignment with the comment on the Discussion section.

“This study offers a comprehensive overview and attribution of the key weather drivers of five extreme wildfire events over Europe in 2025. These events spanned a broad range of weather drivers and extremity of event. In northwestern Iberia, persistent heat followed by moderate winds, in combination with a moist spring and dry summer, contributed to the largest Spanish burned area on record. On the eastern Adriatic and Ionian coast, simultaneous elevated winds and VPD occurred in combination with similar wet spring, dry summer conditions. In both cases, all meteorological drivers were more common than 10-year events. In western and northern Britain, an extremely rare 140-year spring drought and 25-year spring VPD event contributed to the highest UK burned area on record. In Occitania, summer and spring moisture were not extraordinary, but a 70-year VPD event contributed to France’s largest record wildfire in 80 years. In northern and western Türkiye, a moderately dry spring was followed by a 30-year dry summer event which, in combination with rare VPD and HDWI conditions, drove extremely damaging wildfires throughout the region. The case study regions also spanned distinct fire regimes,. These included the European region most prone to large fires in northwestern Iberia; an historically small fire dominated region in Occitania; and western and northern Britain where wildfires predominantly occur in the spring. The studied fire regimes are also changing rapidly, with large wildfires increasing in Iberia and southwestern France, the emergence of a summer fire season in Britain, and the transition of historically humid northern Turkish forest to a drier, more fire prone environment.

Across all of these diverse drivers and different fire regimes, a straightforward increase in the likelihood and intensity was found across many key weather drivers of wildfire. Strong trends towards drier summers were found across the southern European regions. Summer effective precipitation emerged from natural variability in northwestern Iberia, Occitania and northern and western Türkiye (Fig. 11b). Extreme weekly VPD was also found to have increased in frequency across all study region fire seasons. VPD extremes were emergent in the reanalysis data across all regions, and the synthesised trend was especially strong over Türkiye. Despite minor to nonexistent trends in high winds, these shifts in VPD resulted in emergence from natural variability in the hot, dry, windy compound index (HDWI) across the synthesis of reanalysis and climate models in northwestern Iberia, the eastern Adriatic/Ionian, and northern and western Türkiye, and in the reanalysis only for western and northern Britain, and Occitania (Fig. 11a).”