The proposed manuscript focuses on the use of a vegetation dynamics model (LPJ-GUESS) that includes a fire module to estimate potential future changes (by the end of the 21st century) for a region located in the northeastern part of the Mediterranean basin. First, a massive effort is made to analyze historical data to verify that the model accurately simulates the areas burned in the region over the historical period, as well as the fire recurrence interval and the years in which the burned areas are the largest. For this step, several satellite products tracking wildfires are used in conjunction with climate data derived from observed data (ERA5) or simulated data from various GCMs, in order to test them over the historical period as well; this is because, in a subsequent phase, these climate models and their simulations of future conditions will be used in a prospective mode.

Although such an analysis would be very useful, the manuscript, in its current form, is not ready for publication.

Author's Comment (AC): Thank you for your review and constructive feedback. Please find my responses below.

In my opinion, the most significant issues are as follows:

- The discussion section does not cite any references, which is almost shocking when considering submission to an international scientific journal

AC1: I entirely agree with you and have corrected this oversight. While the discussion builds heavily upon simulation results, the conclusions derived are built upon existing and recent research, which in turn corroborate the results. I have revised the Discussion section to properly integrate and cite relevant literature where necessary, reference list have also been appended:

… The simulations presented here suggest that future wildfire dynamics across the Northeast Mediterranean are likely to be shaped less by a uniform intensification of fire activity and more by spatially heterogeneous shifts in fire hazard within distinct ecoregions. While rising temperatures and increasing atmospheric dryness elevate fire probability across much of the region, the resulting fire outcomes vary substantially depending on vegetation productivity, topography, and regional hydroclimatic conditions. This aligns with recent regional climate studies, which indicate that while overall fire weather intensifies (Hetzer et al., 2024), the expansion of fire-prone conditions will be highly heterogeneous across the Mediterranean basin, driven by complex interactions between localized fuels and changing aridity (Ekberzade et al., 2025; Gallo et al., 2026; Ghasemiazma et al., 2026). [Lines 538-546]

… Furthermore, translating these climate-driven projections into actual landscape risk requires acknowledging the role of human land management. Aggressive fire exclusion successfully masks underlying climatic flammability in the short term (Parisien et al., 2020), often at the cost of generating a latent "fire debt" that can fuel high-impact megafires when suppression capacities are ultimately overwhelmed (Ekberzade et al., 2025). [Lines 576-580]

… In this closed-canopy deciduous system, fire activity is therefore not strictly climate-driven; instead, it is strongly fuel-limited (Harrison et al., 2021; Krawchuk and Moritz 2010). Once available biomass is consumed, the system temporarily loses the capacity to sustain fire spread until vegetation regrowth restores sufficient fuel connectivity. This dynamic contrasts with nearby pine-dominated systems, where rapidly accumulating needle litter maintains a continuously flammable fuel bed capable of responding quickly to drought events (Agne et al., 2023). [Lines 657-663]

.. Classical drought theory often predicts that increasing aridity will reduce fuel availability and therefore suppress fire activity (Pausas and Riberio 2013; Bradstock 2010). However, the simulations show simultaneous increases in maximum FAPAR and fire probability across several northern and montane regions. This pattern likely reflects the combined influence of CO_2 fertilization and shifts in vegetation composition (Allen et al., 2024). Elevated atmospheric CO_2 improves plant water-use efficiency, allowing vegetation productivity to remain stable or even increase despite declining moisture availability (Keenan et al. 2013; Donohue et al. 2013). At the same time, warming temperatures may facilitate the expansion of drought-adapted species into previously cooler environments, maintaining canopy density and fuel continuity even under drying conditions (Ekberzade et al., 2024). [Lines 673-681]

… Current fire management strategies in the Northeast Mediterranean prioritize the wildland–urban interface and coastal landscapes where human ignitions dominate (Keeping et al. 2026; WWA, 2025b; San-Miguel-Ayanz et al., 2021). [Lines 688-690]

… Such scenarios could severely challenge existing suppression systems by exceeding the logistical capacity of firefighting infrastructure, particularly during extreme, prolonged heatwave events (San-Miguel-Ayanz et al., 2021; Ekberzade et al., 2025; Ghasemiazma et al., 2026). [Lines 703-704]

-The title refers to fire regimes, but there are several issues here: without the provided definition, a non-specialist reader might assume that the variables analyzed here on their own are sufficient to define and characterize this concept, but that is not the case. These variables are only a subset of the variables that must be analyzed to characterize the regime (fire-season start, end or duration, fire behaviour, fire cycle, and fire type (surface, crown or ground fire are also necessary) so it would be more accurate to mention them without actually referring to the regime. the second problem with the use of fire regime, is that this concept must be characterised at the ecosystem level (so here at the ecoregion level at best), not just at the regional level.

AC2: Thank you for this comment. To clarify, while I agree that a comprehensive fire regime encompasses severity, seasonality, and fire type (surface fire vs crown fire), these parameters are beyond the capacity and the aim of the DGVM framework. However, to make this point clear for the reader, per your suggestion, I added an explanatory paragraph at the beginning of Experimental design section (Section 2.3, lines 125-130) detailing that this study operationally defines the fire regime specifically by its spatial extent (burned area), frequency (FRI), and probability components:

2.3 Experimental design

A comprehensive ecological definition of a fire regime encompasses a broad suite of parameters, including fire severity, seasonality, fire behavior, and fire type (e.g. surface vs. crown fires; Agee, 1996; Krebs et al. 2010). However, simulating this full spectrum remains beyond the mechanistic scope of the specific LPJ-GUESS-SIMFIRE-BLAZE framework utilized here. Therefore, for the purposes of this study, the concept of a fire regime is defined by the subset of variables simulated by LPJ-GUESS-SIMFIRE-BLAZE: burned area (spatial extent), fire return interval (frequency), and fire probability.

Regarding the scale, I agree that ecosystem-level analysis is extremely important when modelling regional wildfire potential. Therefore, as detailed in Section 2.3.3, all historical benchmarking, interannual variability, and temporal analyses were conducted and aggregated at the ecoregion scale (using the 29 distinct terrestrial ecoregions (Fig. 3) that are present within the study area – also shown in Figures 4-9, as well as in Appendix A1-A2, and A5). I have further revised the text to ensure this ecoregion-level analysis is emphasized in lines 28-29 (Abstract); 74-75 (Introduction); and 568-570 (Discussion):

… The findings suggest that climate change may not simply increase overall wildfire activity in the Northeast Mediterranean, but rather systematically redistribute fire risk across its distinct ecoregions, with urgent implications for anticipating emerging hotspots and adapting fire management strategies.

… These simulations investigate whether such climate trajectories will simply intensify existing wildfire activity in the region or drive a fundamental spatial reorganization of fire regimes across its diverse ecosystems.

… This divergence between fire probability, fire frequency, and burned area highlights the importance of considering multiple fire regime metrics simultaneously at the ecosystem level when assessing future wildfire risk.

-Using only the FAPAR variable to represent the vegetation simulated by the model is not sufficient, as it does not necessarily reflect the fuels involved in fires and their spread. The advantage of using a DGVM is the ability to utilize the information provided by Plant Functional Types (PFTs), as this allows for the separation of herbaceous and woody components, and even the distinction between shrubby and tree PFTs if information on the PFTs used and their parameterization is available. However, this is not the case here.

AC3: Thank you for raising this issue. It is a valid point. While I utilized regionally parameterized PFTs to drive the simulations (as noted in the methodology), I agree that relying solely on maximum total FAPAR in the results does not adequately explain the underlying shifts in fuel composition. To address this, I have extracted PFT-specific outputs and introduced a new multi-panel plot (Figure 12). This figure visualizes the evolution of vegetation composition, expressed via Leaf Area Index (LAI) and partitioned into Tree, Shrub, and Grass functional types, across four representative ecoregions. Furthermore, to provide complete transparency and spatial context, I included a comprehensive 29-panel figure in the Appendix (Figure A6) detailing these structural PFT trajectories for each ecoregion within the study domain. Figure 12 and its caption:

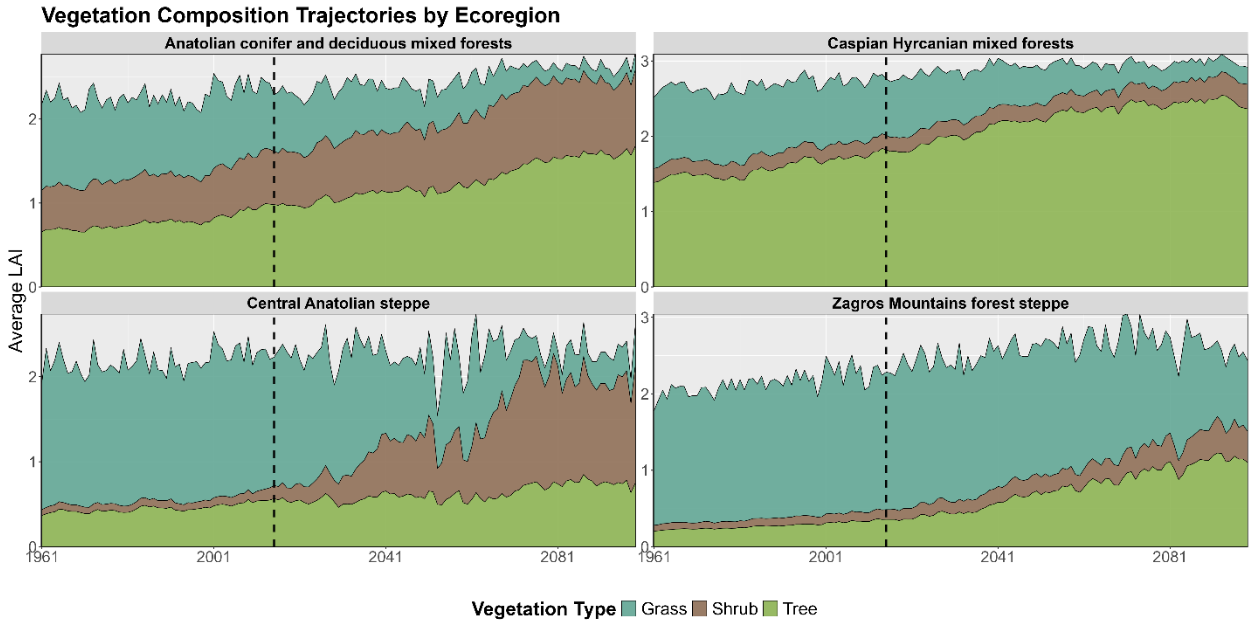

Figure 12. Projected structural vegetation shifts (1961-2100). Plant Functional Type (PFT) trajectories, expressed via Leaf Area Index (LAI) for tree, shrub, and grass categories, across four representative ecoregions. The panels illustrate the distinct ecological reorganizations driving regional fire dynamics under the SSP5-8.5 scenario.

To complement the figure, lines 461-469 have now been added to the manuscript:

A comprehensive analysis of potential Plant Functional Type (PFT) structural trajectories divided into three groups (tree, shrub, and grass) across the 29 representative ecoregions within the domain underscores the magnitude of potential spatial reorganizations. Notably, projections for the Pontic steppe suggest a near-complete transition from an open, grass-dominated landscape to a closed-canopy ecosystem by the end of the century (Fig. A6). The distinct profiles highlight the effect of climate forcing on highly localized ecological reorganizations rather than a uniform change throughout the study area. For example, in historically fuel-limited, semi-arid regions (e.g. Central Anatolian steppe and Zagros Mountains forest steppe ecoregions), the projected increase in productivity is largely driven by grass and understory expansion (Fig. 12).

-The fact that there are ecoregions with a significant human impact—both in terms of land use (agriculture) and the use of fire to clear farmland after harvest—would require excluding these ecoregions from the analysis, or at least, by treating each ecoregion independently as required by the definition of the fire regime, and if aggregation can be necessary, to analyze them separately from other, less anthropized ones.

AC4: I understand your concern regarding the strong human imprint in these specific ecoregions, a notion which is also recognized in the manuscript. However, retaining these human-impacted ecoregions – and comparing them directly against the natural-potential simulations – is a fundamental, deliberate component of the experimental design of this study. As discussed in Section 4.1 ("The Human Gap"), comparing the model's climate-driven potential against the human-impacted satellite reality acts as a diagnostic tool. It allows the quantification of the latent "fire debt" in suppressed forests and the dampening effect of agricultural fragmentation in steppes. Excluding these regions would remove the ability to diagnose this vital anthropogenic divergence. I have, however, adjusted the text in the Methods (Section 2.3.1) section to make this comparative philosophy even clearer to the reader:

… Crucially, heavily managed and agricultural ecoregions were retained in this evaluation rather than excluded to allow the measurement of anthropogenic divergence. [Lines 155-156]

Also, the Results section (Section 3.1.1) mentions the outcome of this approach (Lines 296-298):

… LPJ-GUESS simulations, driven by both historical reanalysis and the GCM ensemble median, reveal systematic fire-regime-dependent divergences when compared to MODIS satellite observations. Despite the central tendency of the GCM ensemble results – maintaining an observation/simulation bias ratio close to 1.0 – **these divergences point to the difference between simulated natural (climate-driven) fire potential and observed fire activity (including human interference), particularly in arid and semi-arid ecoregions** (Fig. 4).

-Apart from the fact that the figures are very small, with captions that are virtually illegible, and that there are already so many of them, additional information should be added in a consistent manner: if the goal is to compare the period at the end of the 21st century with the historical period at the end of the 20th century, the figures presenting the simulations should systematically cover both of these periods, or at least showing the difference, with is not the case everywhere. The most problematic figure is Figure 10, particularly 10a and 10b because this Figure is the only reference to vegetation, but we do not know what types of PFTs this corresponds to, nor their proportions, nor the changes over time or across space....and as a result, this leads, for example, to questionable interpretations regarding "the redistribution of fire regimes".

AC5: Thank you for pointing out the formatting issues, I have increased the font sizes and adjusted the layouts of figures 11 and 13 (now 14 and 16) to ensure they are highly legible. Regarding the temporal comparisons: I would respectfully guide the reviewer to Figure 14 (formerly Figure 11), which explicitly compares the Fire Return Interval for the historical baseline (1961-1990) side-by-side with the end-of-century projection (2070-2100). Furthermore, Figure 16 (formerly Figure 14) explicitly maps the change (future minus historical) in both fire probability and burned area. Additionally, the Supplementary material contains detailed tracking of the spatiotemporal evolution of the underlying climate forcing (e.g. the Hovmöller diagrams in Figures S9-S10, which explicitly map the latitudinal temporal shift of historical drought conditions from the late 20th into the 21st century).

Regarding the former Figure 10 (now Figure 11), as noted in my previous response (AC3) to your previous comment, I have now complemented this visualization with the new plots on PFT-specific data (Tree vs. Shrub vs. Grass LAI). The introduction of these new Figures directly clarifies the specific structural vegetation shifts driving the changing fire hazards over time and across distinct ecosystems.

-If the dominant ecosystem that defines an ecoregion tends to regress inspace, stabilize, or migrate (translate) over time due to the impact of climate change, then we can speak of redistribution; however, if the ecoregion type remains spatially stable over time but fire-related variables (burned areas and their distribution, fire return intervals) change, then we can say that part of the fire regime is changing, but this should not necessarily be understood as spatial redistribution—which, however, is what the author seems to do, in my view, when he discusses this in relation to the firefighting resources currently deployed in certain regions. Actually it is true that they would need to adapt the figting strategy in allocating means differently, maybe, but fire regime changes must be considered in each ecoregion per se.

AC6: Thank you for your comment. I recognize that the term "redistribution" may imply the geographic migration of the ecosystems themselves rather than a shift in where fire activity is concentrated. To resolve this semantic ambiguity, I revised the manuscript to remove instances of "spatial redistribution of fire regimes" (and where applicable, replaced the phrases with "spatial reorganization of fire regimes"). However, when discussing the direct outputs of the simulations and their implications for firefighting resources, I have retained the phrase "redistribution of fire activity," as this accurately describes the shifting spatial concentration of fires without implying ecosystem migration. I completely agree that fire regime changes must be considered within the context of each ecoregion per se, and the text has been tightened to explicitly reflect this.

-I think the author could assist the reader when the reader needs to perform a visual analysis of the maps on their own. The author could use methods that allow for comparing maps in order to highlight areas with positive, negative, or independent correlations, depending on the variables being compared—such as vegetation productivity versus fire risk, or versus predicted or observed burned areas. There are several methods, varying in complexity, for taking spatial information and its autocorrelation into account.

AC7: Thank you for this constructive feedback. As shown in the analysis for drought memory (Figure S8), I frequently employ pixel-by-pixel spatial correlation mapping and coefficient histograms to evaluate spatial relationships across the study area. Similarly, I initially applied this exact spatial correlation methodology to evaluate the relationship between simulated vegetation productivity and fire risk over the 140-year simulation. However, pixel-level mapping over such a long, dynamic temporal gradient introduces significant interannual weather noise that obscured the macro-ecological trends defining the ecoregions. Therefore, to provide the clearest possible assistance to the reader, I synthesized this relationship into a new ecoregion-level correlation scatterplot (Figure 13). By plotting vegetation productivity (Maximum FAPAR) against Maximum Fire Probability, this figure explicitly separates the landscapes and reveals a distinct biome divergence. It clearly visualizes the climate-driven intensification in fuel-limited semi-arid steppes (where productivity increases directly correlate with elevated fire risk due to continuous fine fuel accumulation) versus the "hotter and greener" paradox in flammability-limited environments like the Caspian Hyrcanian forests (where increased productivity drives canopy densification and microclimate cooling, thereby dampening peak fire probability). You may find the new plot, its caption and the paragraph that complements it below. They are in lines 474-485:

These structural shifts drive fundamentally different fire risk outcomes depending on the biome. The correlation analysis showing the relationship between simulated annual vegetation productivity (mean FAPAR) and annual maximum fire probability further highlights the stark ecological divergence between different ecoregions (Fig. 13). In historically fuel-limited, semi-arid regions, the projected accumulation of highly combustible fine fuels potentially results in steep, positive correlations between productivity and fire hazard. Conversely, in the humid, high-elevation Caspian Hyrcanian mixed forests, enhanced growing conditions drive a densification of the broadleaf canopy. In this fire-limited biome, the thicker canopy traps moisture and dampens extreme fire weather, resulting in a negative correlation where increased productivity actually suppresses peak fire probability.

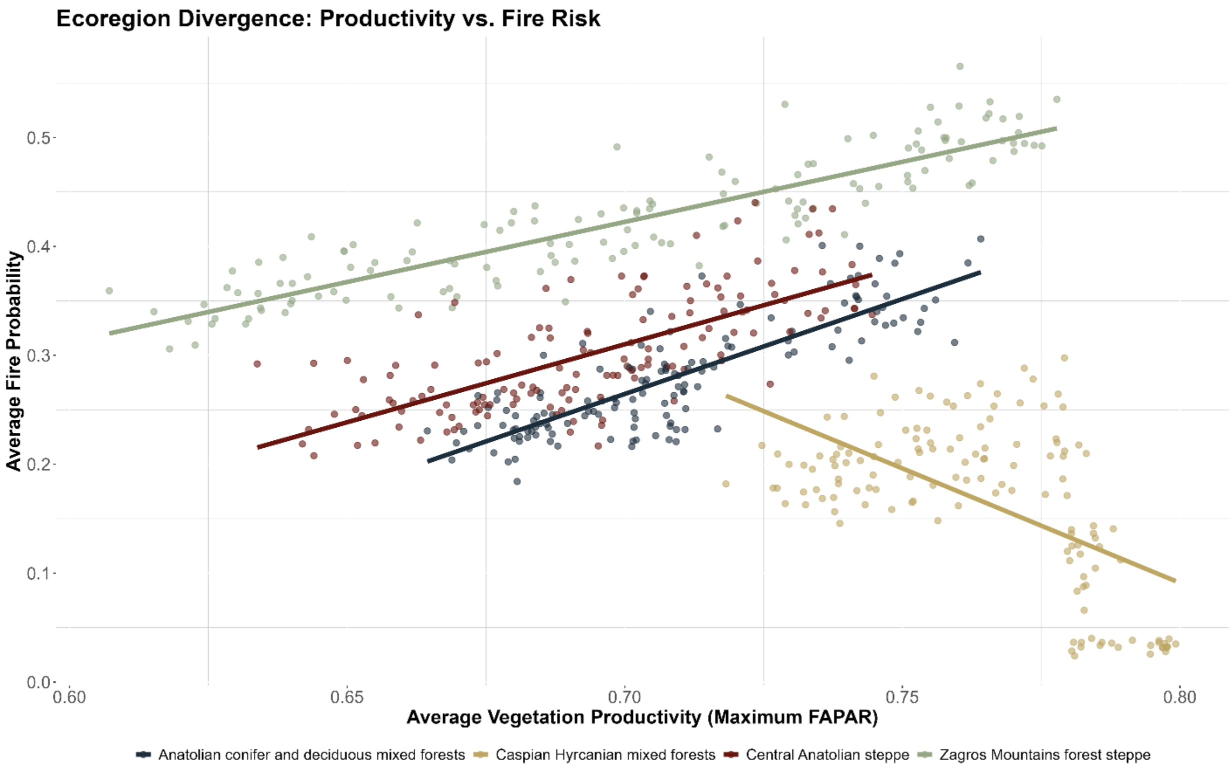

Figure 13. Ecoregion divergence in vegetation-fire feedbacks. Correlation between simulated annual vegetation productivity (mean FAPAR) and annual maximum fire probability (1961-2100). Trendlines illustrate a stark divergence in future wildfire trajectories of four different ecoregions.

In light of all these comments, which I believe are very important, I propose a major revision of the manuscript