Dear Editor and authors,

We (Aragoneses, E; García, M; Salis, M; Ribeiro, LM and Chuvieco, E) appreciate the opportunity to publicly discuss the comments provided by Fernandes et al. regarding our paper, "Classification and mapping of European fuels using a hierarchical, multipurpose fuel classification system" (Aragoneses et al., 2023). While we welcome scientific discussions, we find it necessary to clarify several points and address inaccuracies presented in the critique, as we believe that it merely points out what they consider as flaws our work without any constructive criticism and/or scientifically sound alternative to the methods proposed.

General comments:

Fernandes et al. focused their comment on criticising our work, all their sections, and even some approaches that they considered in their previous published works. They forget and ignore about the limitations and recommendations we underlined in the discussion of our work, misquote several sections of our paper and forget to put it into a proper context. Moreover, the manuscript does not include any new scientific outcomes, as it is only focused on criticising our work. We also find remarkable that the comment of Fernandes et al. did not include many relevant references in the field, including the main paper they are commenting on. This paper is completely based on our original paper, but our paper does not appear in references, which should. Some other general remarks are provided in the following lines:

a. Scientific basis of the criticism: The critique lacks scientific rigor and appears to us more as an opinion piece rather than a robust scientific analysis. It does not provide substantial empirical evidence to counter our methodology or results, as it should happen in papers published in high-impact scientific journals. Instead, it relies on selective examples and subjective statements that cannot be extrapolated to the whole study area, making it more akin to a blog post than a peer-reviewed scientific discussion. The critique selectively highlights a specific area in Portugal where Fernandes et al. claim that our continental fuel map contains errors. We would like to emphasize that our map is covering the European continent and despite our validation efforts demonstrated an overall accuracy of 81%, within the expected range for such large-scale mapping projects, some degree of error is inevitable, particularly when analysed at local scale. Yet, Fernandes et al. regarded our map as inaccurate without providing any systematic validation, which should present a statistical design sample that should cover multiple regions—not just Portugal, or even a small study area of that country— which would be necessary for a fair assessment. The criticism appears to stem from a potential disagreement with our findings based on the reviewers' own familiarity with specific areas, rather than a quantitative systematic validation objective assessment of our product. Another important aspect to consider is that comparing coarse-resolution data with high-resolution data has limitations in terms of the minimum mapping unit and, therefore, products cannot be strictly comparable, as the coarse-resolution data might simplify or aggregate the high-resolution data following specific aggregation rules, as it happens in our case (the rules can be read in our original paper and should be taken into account when comparing).

b. Misrepresentation of our objectives and methodology (hierarchical fuel classification system, fuel map and fuel models): The objective of our work was to develop a common fuel classification system, as well as to show a methodology of mapping fuel types which could be later assigned to fuel models; this methodology could be adapted to different scales. Following this idea, we developed a methodology for mapping fuel types at the European scale and proposing an assignment of those fuel types to surface fuel models based on the categories proposed by Scott and Burgan. Thus, the 1 km resolution map is a demonstration of the methodology, an example of how it could be developed and applied. Should higher resolution and airborne LiDAR data be available, the same classification could be applied at a finer resolution, as it has been done in recent publications following our proposal (Mohammadpour et al., 2025), but at much higher spatial resolution.

c. Timing of the criticism: Fernandes et al. raise concerns that would have been more appropriately addressed during the open discussion period of our original publication. Scientific debate is best conducted in a timely manner when contributions can be made constructively during peer review or public discussions. In this particular case, our original work was opened for public discussion for several months, when we would have been happy to discuss any concerns Fernandes et al could have had.

Following the comment of Fernandes et al., we focused our comments in three parts: the hierarchical fuel classification system, the fuel type map, and the fuel models.

1. Hierarchical fuel classification system: Fernandes et al. misrepresent the intent and structure of our hierarchical fuel classification system. Our approach was designed to be multipurpose, accommodating different applications and different spatial scales. The hierarchical structure allows for scalability offering several hierarchical levels, ensuring that more detailed or generalised classifications can be used depending on the spatial scale of interest, offering the possibility to increase the number and detail of fuel categories if needed for higher-resolution studies but at least sharing the less disaggregated fuel types, as we suggested in the discussion "It also offers high versatility, as it enables mapping fuels with different disaggregation of categories, depending on the detail and quality of the input data, while allowing us to overlap fuel maps for the same area at different scales, which would help the integration and comparison of fuel maps because of the common legend" (pg. 1299).

Furthermore, the assertion that some subcategories are unrealistic fails to acknowledge the possible variability in vegetation structures across Europe. The hierarchical and scale-independent system was designed to accommodate all possible, even if unlikely, vegetation variations and allow flexibility in its application. Even if some combinations may be rare, they can be eventually found, particularly if the detail and quality of the input data are high (or could be "artificially" created, like in gardens). Additionally, the hierarchical design enables easy refinement and adaptation as new data become available. In summary, what we proposed in our work was to generate a European multipurpose and easy-to-use classification scheme following similar ideas previously published by many authors, including the authors of this paper: "when considering the production of a pan-European fuel models map, there must be a standardization of the methodology, the data used, and the maps produced" (Sá et al 2023).

Fernandes et al. also criticised the fact that the map does not reflect the real **fuel-complexity** in its legend. It is obvious that a map at the European scale have inherent limitations as it cannot reflect such fuel-complexity. Any map does reflect the reality with all the details as maps are, especially at this spatial scale, a generalisation of the reality (in terms of their legend), but would happen the same for maps at 100 m or higher spatial resolutions, particularly for surface fuels, which present a very high variability even at metre or sub-metre scales. In fact, the criticising authors have also used land cover maps to map fuels in Portugal, which does not either reflect the real fuel-complexity as those land cover classes represent information aggregated at the pixel level and therefore the fuel categories are a generalisation of the reality (Sá et al 2023). In our paper we remarked this directly in the discussion: "Nevertheless, it must be considered that the grouping of vegetation types into fuel types is a balance between the generalisation of the landscape reality and loss of detailed information, which may not be the most suitable system for all study areas (...) Nevertheless, the input datasets are a generalisation of the complex reality, with their own uncertainties and errors, which are transferred to the final European fuel map (...) However, fuel mapping is still a challenge because of the high spatiotemporal variability in fuels and the need to generalise the great variety of vegetation conditions related to fire behaviour." (pg. 1300). This was also previously done by the main author in Fernandes (2009) "A forest typology developed from the Portuguese National Forest Inventory that combines cover type (the dominant overstorey species) and forest structure".

Specific comments:

L36. We are aware of this, as can be read in the discussion section or our paper and in the general comments section of this letter. As stated in our discussion, maps are always a generalisation of the reality and imply somehow to simplify it, particularly at small cartographic scale as the one used for continental maps. If we wanted to keep all the details it would be impossible to create maps.

L50. This is what we did on our original paper, which is also supported by the authors criticising our paper (Sá et al 2023: "To create the final updated Fuel Models Maps (FMM), datasets necessary include expert knowledge, literature, satellite-derived datasets, empirical and user-defined rules, and fieldwork data. These components are integrated into a comprehensive model that supports the mapping process"). So, it is confusing why the same authors complain later about this aspect if they have used a similar approach before, but at a very smaller study area.

L58. First, even if unlikely, our proposed classification system offers the possibility that, in case that fuel type exists somewhere, it exists a category for it to be mapped. The idea was to develop a classification system that could serve for many cases, although if not all categories need to appear at all maps (that is one the points of versability), as it is the case in the European fuel map at 1 km. Also, the existence of two main hierarchical levels allows for combination of fuel layers, allowing for combinations of fuel layers. Second, Fernandes et al. did a mistake in their comment as the classification system we proposed did not have 60 but 85 fuel types, as can be read in our original paper. In order to create readable and manageable legends and maps, it is needed to synthetise and simplify somehow the information, as was done for the European scale. However, as we stated in the discussion, we welcome further detail and improvements when working at high resolution areas. In our discussion we said "The hierarchical nature of the system aims to define a common fuel type classification for different scales and study areas. It also offers high versatility, as it enables mapping fuels with different disaggregation of categories, depending on the detail and quality of the input data, while allowing us to overlap fuel maps for the same area at different scales, which would help the integration and comparison of fuel maps because of the common legend". Third, fuel descriptors are also described in the fuel parameterisation using the Scott and Burgan assignment and the forest canopy fuel parameters that have been further developed (Aragoneses et al, 2024, 2025), as our paper was the first step towards the complete parameterisation of European fuels and is part of a bigger work. Also, please note that the official name of the so-called "EFCS structure" by Fernandes et al., is the "FirEUrisk hierarchical fuel classification system", as can be read in the original paper and is known among the scientific community. Last, we do not understand why Fernandes et al. say that "distinct grass and shrub fuel types are inappropriately merged within the same classification level" as this is not true. Please see the categories 21,22,23,31,32,33 and all the fuel categories of the second hierarchical level where we distinguished several grass and shrubs fuels both as surface fuels and understory.

2. Fuel type map: Our work was conducted in response to the needs identified by the European Union and the Joint Research Centre (JRC) to improve existing fuel maps at a continental scale. In this sense, our European fuel map is an improvement from the European fuel type map that previously existed that used 10 fuel models based on the NFFL (Northern Fire Laboratory System; Anderson, 1982). The decision to use a 1 km resolution was based on the requirement to integrate various environmental variables within the project in order to integrate all the generated information and help coordinated and comprehensive results. Like our European fuel type map, some of these data included meteorological data as input data, which have coarse resolution. This aspect was further explained in the public revision of our original paper. We copy-paste here what we replied during the discussion: "Although this 1 km resolution might be seen as coarse, it should be noted that the study area is the European continent. The extent of this study area and the available input data makes it difficult to map fuels at a finer scale, especially considering the input data (the CCI LC map at 300 m, the bioclimatic models (including the weather data), etcetera), which led to adopt 1 km as a compromise resolution. It should be considered that the intention to generate a European-scale fuel type map, and corresponding fuel models, is not to simulate the propagation or a specific fire, neither to do strategic fire management at regional or local scales, but to support the estimation of fire risk conditions, based on a holistic perspective of the actual state of fuels in the European territory, that would help to identify areas with higher fire risk conditions and where specific prevention strategies might be adopted to reduce fire risk. In addition, the proposed fuel classification system is hierarchical and multipurpose, referring not only to propagation studies but also to emissions or post-fire recovery, for which 1 km resolution could be a first step to compare fuel and fire risk conditions at a continental scale. Anyway, the classification can be adapted to different spatial scales and in fact, the same legend is being used for Pilot Sites in Europe (regional scales at the FirEUrisk project where the target resolution is 100 m or higher), so it has a scalable structure. Nevertheless, similar methods could be developed to map fuel maps at higher resolution for the European scale in future works."

Given the resolution of 1 km, our European fuel type map is not to be used for simulating fire spread and behaviour of a specific fire event but rather to have a continental overview for the whole European territory. Fernandes et al. should be aware that Rothermel equations have been used to estimate future burnt area conditions in DGVM (Dynamic Global Vegetation Models; see for instance Hantson et al., 2016; Rabin et al., 2017, among others), using much coarser resolutions than 1 km^2 (some at 0.25 degrees). This implies that fire propagation potential can be based on cell conditions, assuming homogeneous conditions and no influence from neighbouring cells. A similar approach has been in fact used in the FirEUrisk project. A paper published in 2023, which we assume the authors are aware of, included examples of such analysis (Chuvieco et al., 2023). These fire propagation potentials have also been used as a component of fire vulnerability in several deliverables of the FirEUrisk project (Arrogante-Funes et al., 2024).

As far as we are concerned, achieving a higher resolution that would allow simulations of single fire spread and behaviour across an entire continent would require geospatial data that is not currently available or is highly uncertain. For instance, homogeneous airborne LiDAR data for the whole continent that would be required to integrate with moderate-high resolution data in order to achieve a high-resolution map needed for fire behaviour simulations, is not yet available. However, at present, our approach remains a compromise given the current limitations. Of course, we encourage other researchers such Fernandes et al to work towards a new high-resolution European fuel map and would be very happy if they could generate it (we are aware that some other European projects are already using similar methods to improve the spatial resolution of a continental-scale European fuel map—Kutchartt et al, (2024)).

Regarding the **fuel depth estimation**, we are aware that it has some limitations, as stated in our discussion. It seems to us that Fernandes et al., once again, misinterpreted our work as if we were not aware of the limitations or have tried to hide them, but Fernandes et al. noticed them. Nothing further from the truth: we were extremely aware that the bioclimatic models were one of the main limitations of our work, as we greatly reflected in the discussion of our paper. However, when writing our paper, we believed that the approach could be reasonable and it was better to have this than nothing (as no European fuel map did exist, nor any large-scale geographical database with the information needed): "Estimating shrubland and grassland fuel bed depth was challenging. To the best of our knowledge, there are no large-scale, reliable datasets in Europe on these variables, which is limiting to our purposes. However, despite the models chosen to estimate surface fuel bed depth not being specifically developed for European areas, the biogeographical similarity of the regions for which they were developed, compared to European conditions, make them acceptable for our purposes. Almost all of the shrubland fuels belong to the arid/semi-arid regime > 83 % of shrubland), which justifies the selection of a bioclimatic model developed for an arid/semi-arid area. To avoid unrealistic estimations, we constrained the outputs to the range 0–6 m for the shrublands and to >0 m for the grasslands, while no maximum cut-off threshold was applied to the grassland category, as the obtained maximum value (1 m) was considered reasonable. In addition, the distribution of shrubland and grassland pixels led to considering the bioclimatic models to be adequate. The histogram for shrubland fuel bed depth showed the continuity of the input variable (precipitation). The histogram for the grassland fuel bed depth had an aggregated structure due to the input productivity data by biogeographic region. Obviously, the direct measurement of the shrubland or grassland fuel bed depth would be more desirable. In this sense, airborne lidar should provide a better estimation, but it is not yet available for the whole European territory, and its temporal resolution may be insufficient to capture the dynamics of these covers." (pg. 1300). Fernandes et al should also be aware that we have published LiDAR estimations of canopy parameters for the same European territory. Even airborne LiDAR data may not be suitable to discriminate heights of shrubs or grass in rough terrains or under dense crown canopies, much less likely is to generate it from space-borne LiDAR systems.

Specific comments:

L71. We encourage Fernandes et al. to read the description of our resampling methods in the paper: "The main resampling criterion was to choose the dominant (first-mode) category within the target pixel. However, to tackle the impact of mixed fuel type covers (e.g. mixed forest), and to take into account the most dangerous type between two equally extended fuel types (discriminated using expert knowledge), the combination of categories in Table 2 was performed whenever there were two co-dominant categories. Co-dominant categories were defined as those that present the same frequency in a group of pixels or if the frequency of the second majority category is higher than half the frequency of the majority category. The combination of the co-dominant categories in Table 2 was carried out regardless of which category had a higher frequency." (pg. 1294). As clarified before, Fernandes et al. are not correct as we did not always use only the majority-rule.

L74 and Figure 1. Incoherences with land cover in Portugal might come from differences in resolution, where different criteria were applied to select the fuel type/land cover. In fact, the critiquing authors have highlighted in a previous paper that the "National fuel model classes fail to describe the vegetation in burned areas of pine forests in Portugal (…). The existing national fuel model classes do not adequately capture this unique vegetation structure and behaviour, necessitating the use of alternative models that better reflect the fuel load and fire behaviour observed in these regions (Sá et al., 2023)". So, this suggests that finding differences between our fuel map and the national information in Portugal could be because national Portuguese information might have some errors as well, neither the national map of Portugal reflects the real fuel-complexity which concerns Fernandes et al. This also reinforces our argument about all maps being a generalisation of the reality and seems to be misunderstood by the authors of the critique.

For the 1 km resolution, some evergreen forest patches inside shrubland masses could have been mapped as shrubland due to generalisation. Of course, we encourage people studying fire behaviour in small study areas to use their own maps at higher resolutions. Please refer to the discussion section in our original paper where we commented about it in previous lines.

It seems to us that there is not much variation within fuels if the locations were Fernandes et al "checked" our fuel map, as they refer to an area within 100 km^2, which represents a 0.002 % of the European territory (our study area). Are these results applicable to the rest of Europe? It seems very weak to state that the whole European fuel map is wrong based on a study done within an area very small and not representative of the whole Europe. It seems to us that this cannot be extrapolated.

Moreover, differences can come from the different definition of categories between our fuel types and the land covers in Portugal. Please notice the definition we used for forest (> 2 m), so trees under 2 m can be considered shrubland. Also, please revise our definition of the "peat and semi-peat land", which includes several things that could have been omitted: (1) wetland, with a permanent mixture of vegetation and water (salt, brackish, or fresh), and marshes, (2) moorland or heathland, with low and closed vegetation cover dominated by bushes, shrubs, dwarf shrubs, and herbaceous plants, in a climax stage of development, and wet heath on humid or semi-peaty soils (peat depth <30 cm), herbaceous vegetation, shrubs, and trees of dwarf growth <3 m, (3) peat land and peat bog, with terrestrial wetlands in which flooded conditions prevent vegetation material from fully decomposing, which results in accumulation of decomposed vegetation matter and moss (peat), including valley, raised, blanket and quacking (floating) bogs with >30 cm of peat layer, and mosses and herbaceous or woody plants within natural or exploited peat bogs, and (4) moss and lichen.

Finally, as Fernandes et al. spotted some lines above, our fuel map is mainly based on Copernicus Global Land cover, so if there are doubts about the accuracy of the data used and discrepancies with the Portuguese maps, the authors should check with the input sources, in this case the ESA, because we used the data from the Copernicus map.

All in all, any map has uncertainties, as we say in the limitations section. We believe that this is a very weak and poor argument to question the overall approach of our original paper, as Fernandes et al. suggest, without providing a sound statistical validation of our product, neither offering any alternative from their own that covers the same extension of ours.

L96. This is again a matter of resolution. If someone wants to do a study of a small study area in detail, then it should be considered all this. If someone wants to do a study on a whole continent, then generalisations are needed, as well as choosing representative shrubs. As stated in our paper, we are aware of these limitations and in fact, we highlighted them (for example we specifically wrote down the R^2 of the models used so that the reader could evaluate if the results were useful for a certain study, not hiding any information from the reader). We also highlighted these limitations in the discussion section for the readers.

L114. The authors do not present evidence about grasslands, not even at the small study area of 100 km^2, so extrapolation of their assumptions cannot be made to grasslands.

L120. Here Fernandes et al., suggests using passive sensors to estimate the height of surface fuels, nevertheless reflectance is not directly related to vegetation height and although empirical models could be developed as in the paper cited by them, a significant amount of field data would be required to develop robust models, especially at the European scale, which was one of the problems we faced for our biophysical modelling. Moreover, the paper cited by Fernandes et al., focused on estimating tree height not grassland or shrubs height

. We agree with Fernades et al. that satellite LiDAR data could help improve the estimation of certain fuel parameters. In fact, this has been the goal of two subsequent research papers in which we integrated GEDI data with satellite (multispectral and SAR) data to estimate critical canopy fuel parameters at European scale. See:

Aragoneses, E., García, M., Tang, H. & Chuvieco, E. (2025) A multi-sensor approach allows confident mapping of forest canopy fuel load and canopy bulk density to assess wildfire risk at the European scale, *Remote Sensing of Environment, 318, 114578, https://doi.org/10.1016/j.rse.2024.114578*

Aragoneses, E. García, M., Ruiz-Benito, P. & Chuvieco, E. (2024) Mapping forest canopy fuel parameters at European scale using spaceborne LiDAR and satellite data, *Remote Sensing of Environment*, 303, 114005, https://doi.org/10.1016/j.rse.2024.114005.

Nevertheless, they should not forget that these data are suitable for estimating canopy parameters, but their potential to estimate surface fuel parameters is limited due to factors such as canopy occlusion, or the fact that the signal from the ground and surface fuels gets convolved in the large footprint of full waveform systems like GEDI, particularly over steep terrain.

L130. Fernandes et al. misunderstood our paper here. One thing is the fuel type classification system: fuel categories, which was developed to serve fire behaviour, risk and emissions. This legend can be applied at different spatial scales, even high resolution. This means that the fuel categories distinguish classes that could be to study fire behaviour, risk and/or emissions (depending on the scale). However, the fuel type map at the European scale was NOT generated with the primary aim of using it for fire behaviour. In our work, we only gave an example of how this legend could be used to map fuel models, but we never suggested, as indicated earlier, that our product should be used t for fire behaviour for individual fires at the European scale. In fact, we did not show ANY result of this, which reinforces that simulating fires was not our intention here. The critique of Fernandes et al. is focusing on some results we did not produce in our paper. Please, see again the lines in the discussion where we comment specifically on this (general comments).

L135. Again, Fernandes et al. misunderstood our work. We never aimed for fire behaviour simulation of individual fires with our European fuel map at 1 km but to have an overview of the fire propagation potential. Our map is not intended for operational tasks but strategic planning. In fact, Rothermel equations have been used at much coarser resolution in DGVM, as indicated above. Of course, the classification system we proposed can be used for fire behaviour modelling if mapping fuels at higher resolutions, but we never aimed to do so with our map. Also, again, in order not to generate a gigantic fuel legend at 1 km resolution we needed to generalise. Even the critiquing authors created discreet categories that cannot reflect the real fuel complexity in a previous work (Sá et al., 2023). Of course, at higher resolutions, more different fuel types could be mapped and are recommended. We commented all this in our discussion section of our paper as can be read in the first lines of this letter.

3. Fuel models: As a general comment about this section, we would like to recall similar works carried out at the EU territory level that used standard fuel models to characterise fuels. On the EFFIS website (https://forest-fire.emergency.copernicus.eu/applications/data-and-services), a "Fuels" dataset for the European territory is freely available and uses only 10 fuel models based on the Anderson (1982) standard models. Our study refers to 18 fuel models (1 of which refers to non-burnable fuels) and is based on Scott and Burgan fuel models (taking into account arid and humid conditions). Another recent work, carried out by Kutchartt et al. 2024, uses 23 fuel models (3 of which for non-burnable fuels) and is based on Scott and Burgan fuel models (taking into account arid and humid conditions). Excluding non-burnable fuels, 17 fuel models (GR2, GR4, GR6, GR7, GR8, GR9, SH2, SH3, SH5, SH7, SH8, SH9, TL3, TU1, TU2, TU3, TU5) proposed in the Kutchartt et al. paper match with the fuel models we proposed in our original paper. GR2, TL2 and TL6 fuel models, which are only present in the Kutchartt et al. paper and not in our work, only cover 6.9% of the mapped territory.

Another key consideration is that in Table 5 of our original paper, that is the crosswalk table, we indicated "Suggested attribution of the first-level FirEUrisk fuel types to the FBFM standard fuel models in Europe", complementing in the main text with "In addition, our proposal of surface fuel mapping and characterisation for the European general conditions can be adjusted or adapted to specific study areas or sites where more detailed information and measurements on fuels or custom data are available" (pg. 1298). In other words, this crosswalk table is a simple proposal, that has limitations and simplifications as many other previous studies, but any user can improve and modify the association fuel type-fuel models simply masking the raster datasets for the areas where a better fuel model type (standard or custom) is available and can therefore propose a different set of values, for single parameters or for the full set of values (dead and live fuel loads, fuelbed depth, moisture of extinction, SAV values, etc.). This idea was also highlighted in the discussion of our original paper: "From this point of view, our proposed approach can be improved in specific areas if customised information and data on given fuel types are available (…). In other words, we propose a generic crosswalk scheme, but users are free to wisely choose or modify the best-fitting standard fuel models according to their study area and expertise or to use different parameters from the standard ones if they have better information for given study areas. Moreover, the main limitation of the crosswalk scheme relies on the reference to general bioclimatic regimes, which are not able to fully consider all inherent differences among European regions in terms of fuel characteristics, while moisture values can be spatially modified according to the specific status of each fuel type" (pg. 1302).

We proposed a structured association that aligns European fuels with existing fuel models to facilitate integration into fire risk management strategies (Chuvieco et al, 2023). This approach is consistent with other studies at similar resolutions and serves a methodological purpose, not an operational one. An example of another European project working at large-scale areas using a similar approach is FIRE-RES (Kutchartt et al, 2024). So, we did never state that this assignment of fuel models should be used always or mandatorily in Europe, as of course we have always been aware that there exist fuel variations within coarse pixels and that should be taken into account at higher-resolution scales. Therefore, the assignment that we proposed was a generic crosswalk. Again, the aim is not to use the European fuel type-model maps for simulations of individual fires (we did not present any result about this), but to have an overview of fuels in the continent, which could be used to have a continental overview of them and took into account for decisions at the EU scale. This is explicitly written in the discussion of our paper: "It is also important to note that the maps of fuel parameters at the European scale are examples of what can be done, but the crosswalk is intended to be useful for areas where technologies and resources such as lidar data are not available. Overall, we highlight that the main use of the map is providing a dataset able to rate fire danger and risk conditions across large geographic areas, while the application of wildfire spread models to very local scales or small areas may pose limitations in the quality of outputs due to the low resolution (1 km resolution) of the fuel input layer" (pg. 1302). In summary, the idea of our paper was that the hierarchical fuel classification system could be used for mapping fuels at the different scales (that can be used for fire behaviour simulation because it includes fuel categories for it) but that does not imply that the fuel map at the European scale must be used for the same purpose.

Specific comments:

L170-175. The fact that the Rothermel's equation is affected by fuel moisture of extinction is well known. The use of standard fuel models of Scott and Burgan (2005) or Anderson (1982) as reference means that the moisture of extinction values (as well as other surface fuel parameters) would be the original ones proposed by those works. This was done in a large set of previous studies and projects that are highly cited and respected in the US as well as in Europe, including several works where the authors of this comment are involved or studies cited in this paper to criticise our fuel models assignments. However, as the authors know, an expert user can customise Scott and Burgan's fuel moisture of extinction values using more appropriate ones, if available.

L175-177. The "arid to semi-arid versus sub-humid to humid climate was fully embraced" by several previous works and papers, also including Sà et al. (2023) and Kutchartt et al. (2024), among others. So, this is a common approach adopted in fuel model mapping to better reflect differences in fuel conditions and characteristics, even if the methods to reach these goals can vary depending on a number of factors, for instance, scales (i.e.: EU vs. National vs. Regional vs. local) and data availability (i.e.: spatial and temporal resolution of weather/climate data). In some fire modelling works carried out at the National level, including some works mentioned in this paper, the differentiation of fuel models into arid vs. humid climate fuel models was not even taken into account.

L180-183. The same consideration could be done for Sà et al. 2023, where the authors of this paper were involved. In that work, for instance, the Koppen-Geiger climate classification was not used for this purpose. Although rainfall in Portugal widely ranges from North to South and from coastal to inner areas, and even if the fuel model mapping was only carried out at the National level, Portugal was simply split into 2 main areas: Atlantic and Mediterranean. In this sense, the suggestion of using Koppen-Geiger data or net primary productivity or more complex ways to differentiate bioclimatic effects on fuels is a good option that can be valid for a large number of works dealing with fuel model mapping.

L183. We cannot find any reference to studies on fuel models of Davide et al. 2020; this work is also not reported in the references.

L190-192. Most of the feedback received for our fuel model maps and the crosswalk between fuel types and fuel models was obtained from experts and researchers from southern EU areas. On the contrary, the feedback provided by experts from Northern and Central Europe countries was less significant, mostly because wildfires in those areas are relatively limited in frequency and size, and few custom data or field measurements of surface fuels were available.

L193. The sentence reporting that the purpose of mapping some surface fuel model parameters is unclear is an opinion of the authors, and it has no scientific strength.

L198. The authors omit to point out that field observations on surface fuels in Central and Northern Europe are limited. And that while a large amount of data could be used for this purpose in Southern Europe, these fuel inventory data are not commonly available for other countries.

L197-201. This is a good but general consideration, and it is valid and applicable for all fuel model mapping works carried out at large scales, such as Regional, National and EU scales.

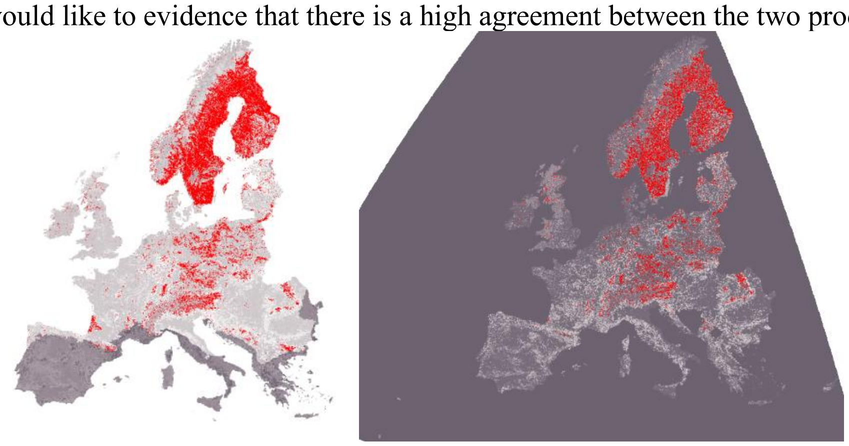
L208-217. The authors used a single case to "prove" this fuel model assignment is not correct. In the Stoof et al. work (published in Dutch, so not easily understandable to non-Dutch readers), at page 31 Stoof et al. report a wind speed of 8.5 km/h, which is much lower than the 15 km/h and 25 km/h proposed in this comment of Fernandes et al. In addition, as the authors know, fuel moisture values play a key role in the rate of spread and fire intensity outputs. The authors did not clarify if the fuel moisture values of 9% for dead fuels and 90% for live fuels were measured or estimated during the fire event, or if it is a hypothetical assignment of the authors. This makes a huge difference, as the authors would like to use this event as a case study to "prove" our fuel model assignment was wrong and that the final fire size would be overestimated. Other fuel mapping works associated herbaceous croplands in wet and semi-humid bioclimatic areas, as in the Netherlands zone for instance, to non-burnable fuels: this was an option that we also took into consideration when preparing our crosswalk table, but at the end we decided to use a burnable fuel to consider potential fires in those areas.

L214-217. Regarding the GR8-GR9 assignment, this was due to the bioclimatic approach adopted, as the rainiest areas were supposed to have the potential of producing taller herbs. But the authors should also consider that usually these herbaceous areas have much higher fuel moisture values than 9% for dead fuels and 90% for live fuels, and that the "moderate moisture scenarios" proposed for their "exercise" have very infrequent probabilities of occurrence for those areas of Europe. This is reflected by fire regimes in Norway, Ireland, and other Northern countries, where according to the crosswalk table, these fuel models could be located.

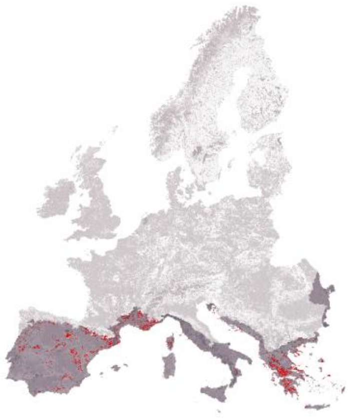
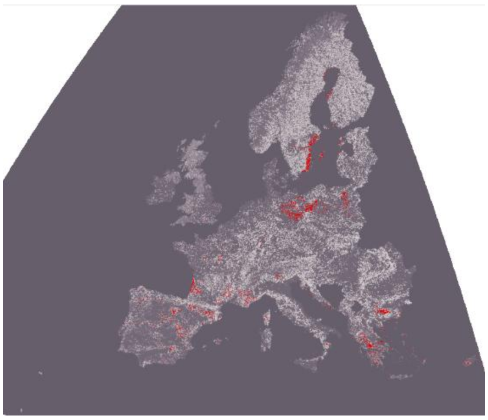
L218. This part of the comment has no relevance, as TU4 is not present in the raster file of our fuel model's map. Probably the authors did not check the fuel model raster maps using GIS tools.

L219-222. Again, the authors decided to omit the role played by fuel moisture in Rothermel's equation and compared the rates of spread of different fuel models located in different bioclimatic areas without fixing this key parameter of the Rothermel's equation, or without considering the differences in fire regime and fuel moisture conditions between humid and arid areas.

We also analysed if other similar works used a comparable approach and obtained comparable spatial results to the one obtained in our paper for TU1 or TU2. Focusing on TU2, regarding the spatial assignment of fuel models proposed by our paper (figure on the left) and the one of Kutchartt et al. 2024 (on the right), we would like to evidence that there is a high agreement between the two products (TU2 is highlighted in red).



Focusing on TU1, the spatial agreement between our paper (figure on the left) and the work of Kutchartt et al. 2024 (on the right) is also high for Southern Europe (we only proposed TU1 for arid climate conditions). TU1 is highlighted in red.

L231-236. The fact that the authors criticise our crosswalk table for some fuel models, here and in other parts of the work, mentioning a single paper is not scientifically sound. We can find several papers and projects where the fuel model assignment to fuel types is close or aligned with our proposal. In other words, nobody has the truth in his hands regarding fuels, and all fuel model mapping works present a given extent of errors, simplifications and generalisations. Even working at the best levels of resolution and details or even using many field data or fuel inventories, capturing the spatial and temporal variability of fuel characteristics and moisture is far to be obtained.

L239. In our classification we considered burnt area as nonfuel if the burnt area was very intense, therefore, as bare soil or sparse vegetation: "Nonfuel, which includes permanent waterbodies, open sea, snow, ice, bare soil, and sparse vegetation (<10 %)". Could happened that under burnt tree stands in 2017 could have grown grasslands or resprouting trees in 2-3 years?

Summary: We believe that the introduction and conclusion of Fernandes et al., are not significant because of the comments we made. In summary, this critique seems to have been carried out by some researchers that are very used to work at the plot scale at very high resolutions, and unfortunately, do not seem to fully understand the need to generalise and simplify at the continental scale, neither the uses that can be given to a European-scale map, which are non-operational but to have an overall continental view. Fernandes et al. have tried to use our work for the same high-resolution fire spread and behaviour modelling of individual fires, which was never the intention of our work, as we advised against doing so. We also encourage Fernandes et al. to re-read our paper with special attention to the discussion, where we originally highlighted almost all the critiques his comment is based on.

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