A global database of extreme fires from satellite data (2003-2022)

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Reviewer 1

General comment

The manuscript presents a global extreme fire dataset from 2003 to 2022, derived from FireCCI51 and MCD14ML. The effort to aggregate global extreme fire data is valuable, while the current manuscript and the dataset have problems in method and structure. My primary concerns are the validity of the dataset and the lack of validation.

Response: We sincerely thank the reviewer for the constructive evaluation of our manuscript. We greatly appreciate the recognition of the value and novelty of compiling a global extreme fire dataset covering the 2003-2022 period, as well as the considerable effort involved in its development. We also appreciate the reviewer's comments regarding the methodology, manuscript structure, and dataset validation. In the revised version, we have carefully addressed these concerns by substantially improving the validation of the dataset and revising the manuscript to clarify the methodological aspects and strengthen its overall structure. We believe that these changes have improved the quality, robustness, and clarity of the manuscript.

Major concern

Comment 1

The manuscript defines extreme fire events based on a 0.25 degree and monthly grid. But extreme fires can cross boundaries and span multiple months. Applying a grid-based approach inevitably divides contiguous fires into multiple parts, thus make it difficult to define as "events".

Response: Thank you very much for this comment. We agree that the terminology used in the previous version could cause confusion between the 0.25° monthly analytical unit and what is generally understood as a "fire event", particularly because fires may extend across several grid cells and/or persist over more than one month, and because several fires may occur in the same grid cell. To solve this potential misunderstanding, we revised the terminology throughout the manuscript and replaced the former Cell-Month Event (CME) with fire cell-month (FCM). Correspondingly, the units previously referred to as Extreme Fire Events (EFEs) at the cell-month scale are now defined as extreme fire cell-months (EFCMs). The FCM is now explicitly defined as the primary geographical and analytical unit used to identify extremes in the database, representing the fire activity aggregated within a given grid cell and month.

The database has also been renamed *Extreme FirEs (EFEs) database*, removing the term "event" from its name. In the intercomparison analysis, the independently documented fire records may correspond to an individual fire, a regional fire complex, or a fire season. Therefore, when comparing these records with the EFEs database, spatially and temporally connected EFCMs were considered together when the documented fire activity extended across more than one grid cell and/or month. This approach maintains the EFCM as the primary analytical unit while allowing broader documented fire occurrences to be appropriately represented in the intercomparison.

The use of a regular 0.25° monthly grid remains a deliberate methodological choice because it provides a globally consistent observational framework and facilitates integration with climatic, environmental, socioeconomic, and Earth system model datasets, which are predominantly available in gridded formats.

Following the reviewer's concern, we clarified throughout the manuscript that the FCM is the primary unit used to identify extremes in the database. This is explicitly defined in **lines 77-79**: *"Each of these cells is hereafter referred to as a fire cell-month (FCM), which is the primary spatio-temporal aggregation unit for determining extremes in this database rather than an individual fire events".* The corresponding extreme unit is defined in **lines 80-81: "***FCMs were identified as extreme fire cell-months (EFCMs) using regionally standardized anomalies of BA and FRP".*

We also clarified how this gridded unit relates to individual fires in **lines 90-91**: *"Consequently, depending on its spatial extent and duration, an individual fire event may cover one or multiple FCMs. Conversely, a single FCM may include fire activity from multiple individual fires occurring within the same cell and month"*, and Section ***"5 Discussion and conclusions"***, **lines 519-524**: *"The FCM is the primary analytical unit of the database, with each FCM aggregating the fire activity occurring within a 0.25° grid cell during a given month. Consequently, an individual fire with extreme behaviour or characteristics may be represented by a single EFCM or by several EFCMs when it extends across multiple grid cells or months. Users may therefore group connected EFCMs according to the objectives and spatial and temporal criteria of their analysis when they aim to analyse broader fire-episodes. In addition, the auxiliary fire patches information derived from FRY may also help users link individual fires to one or more EFCMs".*

The aim of providing a dataset in a gridded format is clarified in Section ***"5 Discussion and conclusions"***, **lines 524-526***: "This gridded framework was adopted to ensure globally consistent observations and facilitate integration with climatic, environmental, socioeconomic, and Earth system model datasets, which are predominantly available in gridded formats".*

Comment 2

The manuscript needs to clarify how multiple satellite overpasses (e.g., Terra and Aqua, day and night) for the MCD14ML product were processed. If these observations are not appropriately deduplicated, it may lead to double-counting and bias the fire radiative power metrics.

Response: Thank you very much for this comment. We have clarified in the revised manuscript how multiple Terra and Aqua observations were handled in the calculation of FRP. Our processing used quality and scan-angle filters to reduce duplicate observations associated with MODIS sampling geometry. In particular, limiting the scan angle to ≤24° excludes the part of the swath where adjacent MODIS footprints overlap, which can lead to multiple detections of the same active fire during a single satellite pass (Li et al., 2018). After this filtering, the remaining valid Terra and Aqua daytime and night-time observations were retained for the calculation of gsumFRP.

We acknowledge that some residual duplication associated with successive satellite overpasses may remain. Studies such as Cunningham et al. (2024) suggest that the magnitude of this residual duplication may be relatively small: their deduplication procedure for MCD14ML active fire detections removed 176,181 likely duplicates from 88.4 million observations, corresponding to 0.19% of the total. Although this proportion cannot be assumed to apply directly to our dataset, it provides a useful reference for the possible amount of residual duplication. This effect is expected to be more relevant at high latitudes, where consecutive satellite orbits overlap more frequently. Since gsumFRP anomalies in our database are calculated independently within each Modified Continental Biome (MCB), any residual influence of these potentially duplicated observations is further mitigated, distribution used to calculate the anomalies is derived from cells located in areas likely having similar duplication patterns (e.g. Boreal regions), rather than comparing fires across regions with widely different latitudes.

Following the reviewer's concern, we have clarified these aspects in section ***"2.1.2 Global Monthly Fire Location and FRP Product - MCD14ML"*, lines 132-137**: "*For our analysis, we applied quality filters to minimise errors associated with scan geometry and thermal source types (Li et al., 2018; Chen et al., 2023): we only used AF pixels with confidence level ≥ 30%, thermal type equal to 0 (vegetation fire), a positive FRP value, and scan angle ≤ 24°, thus excluding MODIS very oblique observations where adjacent scans overlap and may generate duplicate AF detections, while also reducing geolocation errors (Li et al., 2018). After applying these filters, the remaining Terra and Aqua daytime and night-time detections were retained as the final set of AF observations. Next, we calculated the sum of the FRP values of the AFs in each FCM."*, and Section "***5 Discussion and conclusions***", **lines 530-542**: "*Regarding the processing of AFs detections, in our analysis we reduced potential duplicate observations associated with satellite over sampling on high latitudes by applying quality and scan-angle filters. Specifically, we retained detections with a confidence level ≥ 30% (Chen et al., 2023) and limited the scan angle to ≤ 24° (Li et al., 2018). Beyond this angle, adjacent MODIS footprints can overlap by up to 50% towards the edge of the swath, causing the same AF to be detected more than once during a single satellite pass (Li et al., 2018). This filtering reduces this source of duplication, although some repeated observations may remain. Previous analysis of MCD14ML AF (Cunningham et al., 2024), found that when applying quality and deduplication filters, repeated Terra and Aqua detections affected only a small minority of all observations (0.19% of the total). This proportion cannot be assumed to apply directly to our dataset, but it suggests that residual duplication may represent a very small fraction of the total. On the other hand, duplicate observations are more likely to occur at high latitudes, where the coverage of consecutive satellite orbits increasingly overlaps towards the poles. Since the gsumFRP anomalies in our database were calculated independently within each MCB, the potential effect of duplicated observations will be additionally mitigated. In other words, regions where this effect is uncommon, such as tropical regions, are not standardised together with other higher-latitude regions where it occurs more frequently*".

Comment 3

The authors explain that the database ends in 2022 to maintain consistency, given the transition from FireCCI51 to Sentinel-3 products. However, since alternative MODIS products (MCD64A1) are updated in near real-time, ending in 2022 misses recent extreme fire seasons (e.g., 2023 Canadian fire season and 2025 South California).

Response: Thank you very much for this comment. We agree that recent fire seasons, such as the 2023 Canadian wildfires and the 2025 Southern California fires, are of remarkable interest, and we also share the interest in extending the temporal coverage of the database. The aim of the present version is to establish a robust historical reference for the identification and analysis of extreme fire activity using a single, homogeneous burned area product. FireCCI51 was selected not only based on considerations of data quality and temporal consistency, but also because the methodological framework of the database is closely linked to the products generated under ESA's CCI projects. Previous global assessments have also shown lower omission errors for FireCCI51 than for alternative burned area products such as MCD64A1 during the evaluated period (Franquesa et al., 2022).

The 2022 endpoint is also related to the broader transition beyond the MODIS era in relation to the orbital drifting of this satellite, rather than only to the temporal availability of FireCCI51. A similar temporal boundary has been adopted in other global fire datasets. For example, the fifth version of the Global Fire Emissions Database (GFED5) focused its MODIS-based analysis on 2002-2022 (van der Werf et al., 2025), when high-quality MODIS products were available, while its continuation beyond this period required a separate approach based on VIIRS observations (Chen et al., 2026). This illustrates the methodological challenges involved in maintaining consistency when transitioning between successive satellite missions.

In our case, the recent development of MRBA60 (Torres-Vázquez et al., 2026), which harmonizes FireCCI51 and FireCCIS311 into a continuous BA record, provides a possible pathway for extending the EFEs database to more recent periods. Such an extension would require recalculating the reference distributions and extreme-fire thresholds based on this new product, together with the corresponding processing and evaluation needed to ensure consistency. These methodological requirements make this an aspect to be addressed in future versions of the database.

Following the reviewer's comment, we have clarified why the study period ended in 2022 and the use of FireCCI51 in Section ***"5 Discussion and conclusions":***

Lines 543-567: "*The selection of FireCCI51 as the BA data source was guided not only by considerations of data quality and temporal consistency, but also by the methodological framework within which this database has been developed, closely linked to the products generated under ESA's CCI projects. Global accuracy assessments indicate that FireCCI51 presents lower omission errors between 2017 and 2019 than alternative products such as MCD64A1 (Franquesa et al., 2022), with global Dice Coefficient values for these three years of 66.7% for FireCCI51 compared to 62.5% for MCD64A1, making it a more reliable source for detecting extreme fires over long time series. However, because FireCCI51 is based on MODIS data, which has been approaching the end of its lifetime, the FireCCI project started a few years ago the generation of a new BA product based on Sentinel-3 and VIIRS active* *fires (Lizundia-Loiola et al., 2022). This means that the new BA product, named FireCCIS311, as it has a higher detection accuracy and different resolutions (Lizundia-Loiola et al., 2022), is not temporally consistent with FireCCI51 BA detections. Consequently, extending the EFEs database beyond 2022 could introduce artificial discontinuities in the identification and characterization of extreme fires. For this reason, this study limited the database to the 2003-2022 period, defined from a single BA source and therefore internally consistent. Similar temporal boundaries have been adopted in other global fire datasets; for example, the fifth version of the Global Fire Emissions Database (GFED5), focused its MODIS-based analysis on 2002-2022, when high-quality MODIS products were available (van der Werf et al., 2025), while the continuation beyond this period is addressed through the GFED5 near-real-time extension (GFED5NRT), based on modelling BA from VIIRS observations (Chen et al., 2026), and starting the time series in 2012.*

The recent development of MRBA60 (Torres-Vázquez et al., 2026), which harmonizes FireCCI51 and FireCCIS311 into a continuous BA record, may facilitate future extensions of this database to more recent periods. Such extensions would require recalculating the reference distributions and extreme-fire thresholds and evaluating how the new BA record affects the identification of EFCMs across the historical series to ensure consistency across the complete time series. More broadly, ensuring continuity beyond the MODIS era remains an important challenge for the fire science community, as it requires harmonizing long-term satellite records across successive missions (Jones et al., 2024). In this context, the present database provides a historical reference based on the complete FireCCI51 record and establishes the methodological basis for future EFEs databases derived from Sentinel-3 observations and, ultimately, from harmonized BA products as suggested in the literature (Kelley et al., 2025)".

Comment 4

As a data descriptor paper, validation of the product is important and necessary. The manuscript currently primarily focuses on analyses. A cross validation with other data sources (Global Fire Atlas, FIRED), such as disaster databases (e.g., EM-DAT), media news, or regional records, is needed to verify that the identified events correspond to existing records.

Response: Thank you very much for this comment. We agree that the validation and comparison procedures are fundamental to assess the quality of a new dataset. However, it was difficult to carry out a validation for the dataset presented here, as there is no standard or widely accepted definition of what an extreme fire is (Tedim et al., 2018) and therefore there is no reference dataset nor methodology against which to compare our results. Further, the Global Fire Atlas and FIRED are not databases of extreme fires, but rather datasets of fire polygons including all category sizes.

However, following the reviewers' concerns, we have now greatly strengthened the validation and intercomparison strategy. Because no global database provides an established reference classification of extreme fires, the primary comparison was based on an independent set of fires documented as extreme in the scientific literature across different regions of the world during 2003-2022. The same documented fires were then used for additional intercomparisons with other independent databases, allowing us to assess agreements and differences between the EFEs database and these sources for a common set of extreme fires. These included the global EM-DAT database and, for fires occurring in the United States, the FPA-FOD database. We also used complementary scientific, technical, official, and journalistic sources. Below we set out the procedure described in the section "***3.3 Intercomparison analysis", lines 377-430:***

"Because no global database provides an established reference classification of extreme fires, we compiled an independent set of fires documented as extreme in the scientific literature and compared them with the EFEs database. The literature-based reference set included fires that occurred worldwide between 2003 and 2022. We identified fire records through structured searches conducted by year and geographical region, selecting between 6 and 10 fire records per year. The searches combined terms describing the fire phenomenon, such as "wildfire", "forest fire", "bushfire", "peat fire", and "wildland-urban interface fire", with descriptors of extremity and fire behaviour, including "extreme", "megafire", "record-breaking", "high-intensity fire", "rapid spread", "firestorm", and "resistance to control". We also used terms related to pyroconvection, such as "pyrocumulonimbus", "fire-generated thunderstorm", and "fire tornado"; physical fire characteristics, including "burned area", "fire radiative power", "fireline intensity", "rate of spread", "duration", "severity", and "emissions"; and human, material, and economic impacts, such as "fatalities", "injuries", "evacuations", "displacement", "destroyed structures", "economic losses", and "smoke". The procedure did not rely on a single bibliographic database or a fixed search query. We progressively refined the searches by combining these terms with years and the names of countries, geographical regions, and fire seasons to improve the geographical and temporal coverage of the reference set. More detailed terminology, organised by search component, is provided in Table S3.

We included records when we could identify their location and occurrence period and when at least one scientific publication documented the extreme character of the individual fire, regional fire complex, or fire season in at least one biophysical or impact-related dimension. We excluded duplicate records and whenever possible, we cross-checked fire record dates, locations, and reported impacts against an additional scientific, technical, journalistic, or official source.

This method resulted in a reference set of 166 fires records (Table S2). We compared each fire record with the EFEs database using its reported location and occurrence period. We considered a fire record represented in the database when at least a cell classified as an EFCM spatially coincided with the reported affected area during the same month or months. Because the spatial units reported in the literature did not always correspond exactly to the 0.25º grid used in the EFEs database, we based the comparison on geographical and temporal overlap rather than on an exact correspondence with the individual fire extent or perimeter described in the source publications. Nevertheless, whenever corresponding records were available, we additionally verified the spatial match using fire patch from the FRY database.

As an additional intercomparison, we used the same literature-based fire records as a common reference to compare the EFEs database with other independent databases that include information on different aspects of fires, such as societal impacts or fire size. We retained this common reference because the inclusion criteria of these databases do not ensure that all their records correspond to fires documented as extreme. For this purpose, *we searched the 166 fire records in EM-DAT, a global disaster database that compiles information from United Nations agencies, governmental organisations, research institutes, insurance companies, and media reports (Delforge et al., 2025). We filtered EM-DAT records by the disaster group "Natural", the disaster subgroup "Climatological". Within this classification, we considered the three wildfire subtypes available in the database: "Forest fire", Land fire (Brush, Bush, Pasture)", and "Wildfire (General)". We then searched for corresponding records using the affected country or administrative region, year, occurrence dates, and, when available, the fire name. When we found that a literature-based fire was also documented in EM-DAT, we included its corresponding identifier in our records (Table S2).*

In addition, we carried out a comparison for the 41 literature-based fire records that occurred in the United States (US) using the Fire Program Analysis Fire-Occurrence Database- FPA-FOD v6 (Pourmohamad et al., 2023a). FPA-FOD is a comprehensive source of georeferenced wildfire occurrence data for the US and integrates fire reports from federal, state, and local agencies with fire protection and reporting responsibilities. We searched and matched each fire record using the fire name, year, occurrence dates, and reported location. When several FPA-FOD records had similar names or dates, we also considered their final fire size to identify the most likely correspondence.

FPA-FOD does not explicitly classify fires as extreme, but it provides their final fire size and an associated size class ranging from A to G, with class A corresponding to the smallest fires and class G to the largest. To assess whether the literature-based fires were among the largest fires recorded in the US, we calculated fire-size percentiles using all FPA-FOD records from 2003 to 2020, corresponding to the temporal coverage available in the version used (Pourmohamad et al., 2023b). The percentile indicates the relative position of each fire within the national distribution of recorded fire sizes. For example, a fire in the 99th percentile was larger than approximately 99% of all fires recorded during the analysed period. For each literature-based fire in the US for which a corresponding record was identified in FPA-FOD, we recorded its fire-size percentile and associated A-G size class (Table S2).

The intercomparison was challenging because the sources differ in their inclusion criteria and because comparable information on physical, ecological, human, and socioeconomic characteristics was not consistently available for all fire records. In addition, some fires may be documented as catastrophic primarily because of their impacts rather than their burned area or intensity."

Finally, we also considered the reviewer's suggestion to compare the EFEs database with satellite-derived products such as the Global Fire Atlas and FIRED. However, these products, like the FRY dataset, provide information on individual fires or fire patches derived from satellite observations but do not distinguish between ordinary and extreme fires. Therefore, they cannot be used directly to validate whether the fires identified in our database should be classified as extreme. Applying the same extreme fires detection methodology to these products would essentially reproduce our own methodological framework using a different set of satellite-derived fire objects, rather than provide an independent validation of the resulting EFEs database.

To our knowledge, no global satellite-derived database currently provides an independent and established classification of extreme fires that is directly comparable with the EFEs database. We therefore consider that the revised multi-source strategy provides an appropriate and transparent validation framework. It combines a compiled literature-based reference set, geographical and temporal comparison with the EFEs database, comparison with EM-DAT, and regional evaluation using FPA-FOD.

The detailed information on the fire records and their correspondence with the different databases and the search terminology used to compile the reference set have been added to the revised manuscript and the "**Supplementary material"**, specifically in **Table S2** and **Table S3**, while the comparative results are presented in Section **"*3.3 Intercomparison analysis*".**

Minor comments

- **L13: The phrase "as their characteristics vary depending on the region considered" may not be necessary, as it is somewhat ambiguous and does not introduce new information.**

  Response: Done. This part has been deleted.

- **L14: The description "a global dataset of extreme fires in NetCDF format containing monthly rasters on a regular grid with a spatial resolution of 0.25 degrees" could be more concisely written as "a global monthly and 0.25-degree extreme fires dataset in NetCDF format."**

  Response: Done.

  Line 16: *"a global monthly extreme fires dataset at 0.25-degree in NetCDF format"*

- **L22: Please clarify why "main global biomes" is used here, given that the database claims global coverage.**

  Response: Done.

  We have clarified that the cover is indeed global. **Lines 22-23**: *"in order to account for spatial and seasonal differences in fire activity at global scale".*

- **L24: Please avoid using ambiguous words such as "certain". It is better to list them explicitly.**

  Response: Done.

  We have replaced the ambiguous expression "a certain attribute" by explicitly listing the attributes used to identify extreme fire perimeters. **Lines 24-26**: *"Further, for each EFCM, the database also indicates whether any extreme fire patch overlaps that cell. The fire patch information was derived from the FRY v2.0 dataset, where extreme patches were identified according to fire size, duration, median FRP, rate of spread and severity".*

- **L27: I have reservations about the dataset's value for forecasts and projections, given that it is not updated in (near) real-time.**
  Response: Done.

  We agree that the database is not intended for near-real-time forecasting. We have therefore revised the sentence to emphasise its primary applications for analysing the spatial and temporal patterns of extreme fires, investigating their drivers and impacts, and supporting the evaluation and representation of extreme fire activity in Earth System models. This has been clarified in **lines 27-29**: "*The dataset is intended for climate and Earth System modellers aiming to analyse and evaluate the spatial and temporal patterns of extreme fire activity".*

- **L45: The term "unique" should be clarified: does it mean unified, comprehensive, or broadly accepted?**

  Response: Done.

  We agree that the term "unique" was ambiguous. To avoid this ambiguity and improve the flow of the introduction, we removed the sentence. The following sentence already conveys the intended idea by describing the different criteria that have been proposed to define and characterise extreme fires. This has been clarified in **line 46-47**: *"Different criteria have been proposed to characterise these fires, considering parameters such as fire size".*

- **L47: It would be valuable to mention the fire's impacts here.**

  Response: Done.

  We agree that the impacts of extreme fires represent an important aspect in the literature. We have therefore revised the sentence to acknowledge that, in addition to physical characteristics such as fire size, intensity, and suppression capacity, some studies also consider the associated societal and environmental impacts when characterising extreme fires. This has been clarified in **lines 48-49**: "*with some approaches also considering their associated societal and environmental impacts".*

- **L52-54: A region-specific threshold may also not fully resolve this issue, as it primarily highlights anomalies relative to the region's historical average rather than absolute physical extremes.**

  Response: Done.

  We used a regional approach because we intend to identify anomalous fire activity within the historical context of each region, recognising that different regions of the world present different patterns of fire activity, commonly referred to as fire regimes, and therefore that the characteristics of extreme fires may vary across the world. Dividing the world into regions allows us to identify fires with extreme characteristics relative to the typical fire activity of the region where they occurred. If extremes were classified globally, some regionally exceptional fires might not be identified as such because they would be compared with regions where fires are typically larger or more intense.

Still, as the reviewer points out, identifying extreme fire activity using region-specific thresholds implies that extremes are defined relative to the regional distribution rather than according to a single absolute physical threshold. These regional differences obviously depend on the regionalization chosen, which could be quite diverse, both in terms of the criteria used to define the regions (e.g. biophysical characteristics, administrative boundaries, or pyromes) and the number and spatial extent of the resulting units. The criterion used here was intended to represent the diversity of regional fire activity, which is closely related to the concept of extreme, by identifying fire activity that is both anomalous and characterised by high BA and FRP within its corresponding regional context.

We chose modified continental biomes because we consider this division of the world to provide a reasonable representation of areas with similar climatic and biophysical characteristics and contrasting fire regimes. The dependence of the resulting classification on the selected regionalization should therefore be considered when interpreting the database and is reflected in the recurrent EFCMs highlighted at the end of the section ***"3.2 Spatio-temporal analysis of Extreme FirEs (EFEs) database"***.

We have therefore revised the sentence to clarify that the limitations of global thresholds arise from differences among regional fire regimes, since fires of similar size or intensity may be relatively common in some regions but have disastrous impacts in others. This has been clarified in **lines 53-56**: *"Consequently, the use of unique global thresholds may not be suitable to characterize extreme fires essentially because the actual effects of those extreme episodes may be quite different depending on regional fire regimes: large or intense fires may be relatively common in some regions, but may have disastrous impacts in others".*

- **L54-56: Please clarify this sentence. Small fires in fuel-limited regions are typically not considered extreme, so the current phrasing is slightly confusing.**

Response: Done.

We agree that the original wording was unclear. We have revised the sentence to better explain that the limitation concerns the use of global fire-size thresholds. The revised text now clarifies that, in fuel-limited regions, fires may not reach very large extents even under negative climatic conditions, so global fire-size thresholds may fail to identify fires that are exceptional within their regional fire regimes. This has been clarified in **lines 56-58:** "*In addition, fires in fuel-limited regions (e.g., deserts or agricultural areas) may never reach large extents (e.g., > 10,000 ha), even under fire-prone climatic conditions. Consequently, global thresholds based on a fixed fire size may fail to identify fires that are exceptional in those regions".*

- **L62: This appears to be an incomplete sentence as it only includes landscapes**

  Response: Done.

  We have revised the sentence. This has been clarified in **lines 64-65**: *"Therefore, even though extreme fires occur sporadically, these events can play a disproportionate role in shaping landscape patterns and ecosystem structure"*.

- **L63: The text says "several" but provides only one reference. Please include additional relevant datasets, such as the Global Fire Atlas and FIRED.**

  Response: Done.

  We have revised the text to include additional examples of global satellite-derived fire products and products that reconstruct individual fire patches. This has been clarified in **lines 67-72:** "*In recent years, several global products on fire activity derived from satellite observations have been released including BA products such as MCD64A1 (Giglio et al., 2018) and those developed within the FireCCI project (Lizundia-Loiola et al., 2020; Lizundia-Loiola et al., 2022), as well as active fire (AF) products derived from MODIS and VIIRS (Chuvieco et al., 2020). In addition, these datasets have been used as input to generate products that reconstruct individual patches, such as the Global Fire Atlas (Andela et al., 2019), FIRED (Balch et al., 2020), and FRY (Laurent et al., 2018), thus facilitating the analysis of fire impacts and drivers"*

- **L66-68: The necessity of mentioning the specific ESA project here is unclear.**

  Response: Done.

  We have revised the text to clarify that the EFEs database was developed within the framework of the XFires project, in order to fill a gap in knowledge. This has been clarified in **lines 72-75**: "*However, the analysis of extreme fires remains limited, due to both the lack of a standard definition of their characteristics and the absence of dedicated databases that would facilitate the analysis of different fire typologies and drivers. To address this gap, the aim of this paper is to present the first version of the global Extreme FirEs (EFEs) database, developed as a new global resource within the framework of the ESA XFires project".*

- **L70: This expression is physically imprecise. Multiple distinct fire events can occur within a single month and a 0.25° cell, so aggregating them as a single 'event' introduces artificial artifacts.**

  Response: Done.

  This issue has been addressed through the terminology revision described above and further clarified in **lines 77-79**: "*Each of these cells is hereafter referred to as a fire cell-month (FCM), which is the primary spatio-temporal aggregation unit for determining extremes in this database rather than an individual fire events*", and in **lines 90-91**: "*Consequently, depending on its spatial extent and duration, an individual fire event may* *cover one or multiple FCMs. Conversely, a single FCM may include fire activity from multiple individual fires occurring within the same cell and month*". We have also addressed this issue in Section "***5 Discussion and conclusions***", **lines 519-524** (***See the response to Comment 1***).

- **L81: By using a 0.25° and monthly resolution, a single, contiguous large-scale fire event is inevitably fractured into multiple CMEs. The authors should explicitly discuss this limitation and how it impacts the definition of an "event".**

  Response: Done.

  We have clarified that an individual fire may extend across several spatial and temporal units and therefore be represented by more than one FCM. This is explicitly stated in **lines 90-91**: *"Consequently, depending on its spatial extent and duration, an individual fire event may cover one or multiple FCMs. Conversely, a single FCM may include fire activity from multiple individual fires occurring within the same cell and month."*

  We have also clarified the implications of this representation in Section **"*5 Discussion and conclusions*"**, **lines 519-524.** (**See the response to Comment 1**).

- **L82: Why use the word "roughly"? Geographic divisions should be precise and accurate.**

  Response: Done.

  Following the reviewer's concern, we have changed the sentence avoiding the use of the term "roughly" and pointing the reader to the detailed explanation on the construction of the regions used **lines 92-93**: *"the world was divided into 55 regions corresponding to continental biomes (with some modifications, see details in Section "2.3 Geographic division of the world")".*

- **L87-89: By providing only binary values rather than standardized anomalies, the dataset's usage for diverse modeling purposes is restricted.**

  Response: The purpose of these variables is to indicate whether the fire-patches associated with each EFCM exhibit extreme characteristics in terms of fire size, duration, mean FRP, rate of spread, or severity. A binary representation was adopted because a single EFCM may overlap with one or several FRY v2.0 fire patches. In such cases, assigning a standardised anomaly to the EFCM would require an additional aggregation rule, such as selecting the maximum, mean, or dominant fire-patch value, which would introduce an arbitrary methodological choice. The binary indicators instead provide an unambiguous description of whether at least one associated fire-patch is extreme for each attribute. Users requiring the original quantitative values or standardised anomalies at the fire patch level can obtain them directly from FRY v2.0.

  We have improved this explanation in Section ***"5 Discussion and conclusions"***, **lines 513-518**: *"However, a single EFCM may be associated with one or several fire patches.*

Assigning one quantitative patch-level value to each EFCM would therefore require an additional aggregation criterion, such as selecting the maximum, mean, or dominant fire patch, introducing methodological choices beyond the scope of the present dataset. Fire patch characteristics are consequently represented as binary indicators showing whether at least one associated fire patch exhibits an extreme value for each attribute, while the original quantitative variables remain available in FRY for more detailed analyses".

- **L89: This implies the added value is merely calculating anomalies for the existing FRY v2.0 dataset.**

  Response: The added value is not limited to calculating anomalies from FRY v2.0. The EFEs database spatially and temporally links the FRY fire patches to the corresponding FCMs and integrates this information with the BA and FRP criteria used to identify extreme fire activity. This allows users to determine directly which fire characteristics are associated with each extreme FCM without having to independently process, regionalise, standardise, and spatially intersect both datasets.

  We have improved this explanation in Section ***"5 Discussion and conclusions"*****, lines 510-512:** "*It allows users to directly identify which fire characteristics are associated with each EFCM without independently processing, regionalising, standardising, and spatially intersecting the original FRY fire patch data with the gridded monthly dataset".*

- **L95: It is uncommon to have a one-sentence paragraph. Please merge or expand.**

  Response: Done.

  We have expanded on the explanation in the **lines 105-107:** "*To construct the EFEs database, we used data from three main datasets providing information on fire activity at a global scale during the period 2003-2022. These datasets include gridded BA and FRP information, and individual fire patches characteristics".*

- **L107-110: While the authors justify stopping at 2022 due to the discontinuity between FireCCI51 and Sentinel-3 products, relying on a discontinued product restricts the database's reuse value. Given that alternative MODIS BA products are updated in near real-time, the 2003-2022 cutoff misses critical recent extremes.**

  Response: Done.

  We have clarified this limitation and the rationale for prioritising temporal consistency in the Section ***"5 Discussion and conclusions",*** **lines 543-567** (**See the response to Comment 3**).

- **L116-120: The issue of multiple overpasses (Terra and Aqua for day and night) seems completely unaddressed. Without proper deduplication, fire metrics are systematically biased and double-counted.**

We have clarified this point in lines in section ***"2.1.2 Global Monthly Fire Location and FRP Product - MCD14ML"***, **lines 132-137** and Section ***"5 Discussion and conclusions"***, **lines 530-542**. (**See the response to Comment 2**).

- **L122-138: The added value of including FRY v2.0 is questionable, as end-users could calculate anomalies more straightforwardly from the original FRY v2.0 data.**

  Response: Certainly, the users could calculate standardised anomalies from the original FRY v2.0 data, but doing so would not directly link with the spatial and temporal unit of the EFEs database. The main unit of analysis in our dataset is the FCM, whereas FRY v2.0 is organised by individual fire patches. We therefore use FRY v2.0 information as a complementary descriptor by linking each fire patch to the FCM or FCMs with which it overlaps and indicating whether at least one associated fire patch is extreme for each fire attribute. This integration makes the information immediately usable alongside the gridded BA and FRP variables and is particularly relevant for applications based on regular spatial and temporal units, including climate and Earth system modelling. An analysis based exclusively on individual fire perimeters would represent a different data structure and would not provide the same compatibility with gridded environmental datasets. On the other hand, the actual delimitation of fire patches includes uncertainties, depending, for instance, on the temporal criterion used for cutting-off contiguous burned pixels.

  We have improved this explanation in Section ***"5 Discussion and conclusions"***, **lines 508-513:** ***"****. This linkage provides information on fire size, duration, median FRP, rate of spread, and severity, while preserving the FCM as the primary unit of the database and using the associated patches only as an auxiliary source of descriptive information. It allows users to directly identify which fire characteristics are associated with each EFCM without independently processing, regionalising, standardising, and spatially intersecting the original FRY fire patch data with the gridded monthly dataset. Moreover, because FRY is derived from the same FireCCI51 BA product used in the EFEs database, the cell- and patch-level information remains consistent throughout the reference period".* ***Lines 516-518****: "Fire patch characteristics are consequently represented as binary indicators showing whether at least one associated fire patch exhibits an extreme value for each attribute, while the original quantitative variables remain available in FRY for more detailed analyses".*

- **L176-182: The merge and divide procedure introduces arbitrary thresholds (e.g., why exactly 125,000 km²?), and its added value over a standard continental-biome approach is unclear.**

  Response: The reason behind merging small continental biomes to larger ones was essentially to avoid having regions that were too small and have little relevance for the global analysis. The bioregions that were merged into larger ones comprise mainly mangroves, and other cases such as Tropical and subtropical coniferous forest andTropical & Subtropical Grasslands, Savannas & Shrublands in Asia. These regions tend to be both small and very fragmented (e.g. in the case of mangroves, they are formed of very small patches distributed along the coast). On the other hand, very large continental biomes spanning the northern and southern hemispheres like the Tropical & Subtropical Savannas of Africa with markedly different fire seasons and very heterogeneous fire activity (Andela et al. 2014). We consider that, by dividing these regions into northern and southern hemispheres we limit the challenge described above related to use of the regional approach of identifying extreme fires in regions with highly heterogeneous or unbalanced fire activity.

Following the reviewer's concern, we have strengthened the explanation on the rationale for constructing these modified continental biomes. **Lines 194-196**: *"This threshold was adopted to avoid very small and highly fragmented regions (e.g. mangroves, tropical and subtropical coniferous forests, and tropical and subtropical grasslands, savannas and shrublands in Asia), which would not provide sufficiently representative units for the calculation of regional fire anomalies".* **Lines 198-199:** *"Further, we divided the African and South American savannas and deserts into their northern and southern hemisphere regions to account for their different fire seasons and highly heterogeneous fire activity".*

Reviewer 2

General comment

The paper by Solano-Romero et al. presents a global database on extreme fires events between 2003 and 2022 derived from satellite data. No such database exists and would be valuable for global comparisons, same as a broadly used definition of "extreme fire events". Still the validation of the data set is weak, and needs to be improved. I recommend some minor changes in the meta data. The manuscript itself is written in a clear and accessible way, describing detailed the data source and workflow. The results and discussion section should be structured in a more data set supporting way, and potential and limitations should be better highlited. Overall I see the potential of the database, and recommend the publication after major revisions. Major concern is the validation of the data.

Response: We sincerely thank the reviewer for the careful and constructive evaluation of our manuscript. We appreciate the positive comments regarding the novelty and potential usefulness of the dataset, as well as the clarity of the manuscript and the detailed description of the methodology. We also appreciate the reviewer's suggestions concerning the validation, metadata, and the structure of the Results and Discussion section. These comments have been carefully considered and have helped us improve the manuscript. Our detailed responses to each point are provided below.

Major concern

Comment 1

Section 3.1: The results section primarily describes the shown figures, which seems redundant to me having them in there. It would be more interesting to verbally compare the results of the figures with the intention to show the potential use of the data. For

example Fig 3, 4, and 5a show global occurrences and frequencies but don't give any hint why this would be interesting. Fig 5b suggests a seasonal pattern, while it's questionable to look at this pattern globally. Same goes for Fig 6 and 7: why is this interesting, what is the potential question this analysis could answer?

Response: Thank you very much for this comment. We agree that the previous version of Section 3.1 focused mainly on describing the figures. We have therefore substantially revised the section ***"3.2 Spatio-temporal analysis of Extreme FirEs (EFEs) database"*** to place greater emphasis on the analytical potential of the database and on the comparisons that can be derived from the different spatial and temporal dimensions represented in the figures. In particular, the revised text now illustrates how the database can be used to locate and characterize extreme fire cell-months (EFCMs), examine their temporal variability at different spatial scales, compare both the absolute and relative occurrence of extreme fire activity among MCBs, and assess differences in EFCM dynamics among similar biomes across continents. We have also clarified that the global monthly distribution provides a general reference and that fire seasonality can be more appropriately examined by region, biome, or hemisphere. In addition, the section now highlights the possibility of combining these temporal patterns with climatic, environmental, socioeconomic, and other time-varying information to investigate factors associated with extreme fire activity. These changes have been incorporated throughout Section ***"3.2 Spatio-temporal analysis of Extreme FirEs (EFEs) database"***, **lines 279-369**.

Comment 2

Section 3.2: Due to the lack of a comparable data set and coherent definition it is valid to compare the EFEs data to literature documented events. Still, the validation of a global data set covering 20 years on only 20 events is too week and needs to be corroborated by more evidence. For example simple statistical thresholds from other data sets could be used or part of the data compared with locally restricted data sets like US FPA-FOD for the USA or the EFFIS Large Fire for Europe (ideally based on different satellite products). Discussing differences to the validation data sets the strengths and weaknesses of the new EFEs database could be pointed out better.

Response: We agree with this comment. As also raised by **Reviewer 1**, we have substantially revised and expanded the validation and intercomparison analysis. In the revised manuscript, Section ***"3.3 Intercomparison analysis"*** now provides a detailed description of how the literature-based reference set of 166 independently documented fire records was compiled and how each record was compared with the EFEs database using its reported location and occurrence period. A fire record was considered represented in the database when at least one EFCM overlapped the reported affected area during the same month or months, with FRY fire patches additionally used to verify the spatial correspondence when available. We also describe the complementary comparison of the 166 literature-based records with EM-DAT and, for the subset of fire records that occurred in the United States, the additional evaluation using FPA-FOD, including the fire-size percentile analysis for the matched fires. The complete methodology and results of the procedure are detailed in section "***3.3 Intercomparison analysis"***. The detailed information on the fire records and their correspondence with the different databases and the search terminology used to compile the reference set have been added to the revised manuscript and the "**Supplementary material"**, specifically in **Table S2** and **Table S3.**

In addition, we have expanded the discussion to interpret the results of these comparisons, including the independent support they provide for the identification of extreme fire activity in the EFEs database, the reasons why complete agreement among the different sources is not necessarily expected, and the limitations associated with comparing satellite-derived fire activity with databases based on fire size or human and socioeconomic impacts.

These changes are included in Section ***"3.3 Intercomparison analysis"***, **lines 377-482**, and in Section ***"5 Discussion and conclusions"***, **lines 576-597**. A detailed description of the revised procedure and the corresponding changes is also provided in our ***Response to Reviewer 1***, ***Comment 4***.

Minor comments

- **L 84: Which standardized method was used?**

  Response: Done.

  We have clarified that the standardised anomalies were expressed as z-scores calculated over the entire time series, independently for each region and fire variable.

  This clarification is reflected in the **lines 93-95**: *"Thresholds of BA and sum of FRP were calculated independently for each region and fire variable using standardised anomalies expressed as z-scores calculated from the average and the standard deviation (after logarithmic transformation) of the complete time series".*

- **L 196: "based on standard deviations from the mean" → what is the mean based on? Whole time period or other?**

  Response: Done.

  We have clarified this part in the **lines 214-216**: *"EFCMs were identified from the z-scores of gBA and gsumFRP values, calculated independently for each MCB using the mean and standard deviation of all FCMs within that region over the reference period (2003-2022). These regional thresholds aimed to separate normal and extreme fire activity".*

- **Fig 1: Seems to have many colors, reduce to two or three.**

  Response: Thank you for this comment. This figure indicates the different regions that were used as geographical units, which amount to 55. While we appreciate the figure contains many colours, the objective of the figure is to distinguish and facilitate the location of each one of the figures

- **L 178: The meaning and use of "social heterogeneity" is not clear to me as the focus in the workflow lies on climatic and ecological factors.**

  Response: Done.

  We agree that the term "social heterogeneity" was not sufficiently supported by the regionalisation used in the workflow, which is based on global biomes subdivided by continent. We have therefore removed this term and clarified that the regionalisation was intended to capture ecological and climatic differences among fire regimes.

  The revised sentence now reads in the **lines 189-193**: *"Because we aimed to create a database of FCMs that can be considered extreme in different areas of the world, we define thresholds to characterize extremes based on regions with similar fire regimes. More specifically, we used as geographical reference 55 regions based on the global biomes proposed by Dinerstein et al. (2017), subdivided by continent to better capture the ecological, and climatic heterogeneity associated with different fire characteristics".*

Notes on the data set itself

- **I couldn't access the database via the provided link but did find it with description given in the paper. A published data set should be understandable by itself. That's why I recommend to improve mainly the provided meta information in the Readme.txt.**

  Response: We thank the reviewer for bringing this to our attention. The access problem was caused by an update of the repository URL after the manuscript had been submitted. The URL originally included in the preprint was the one provided by the repository at the time of submission and correctly resolved to the dataset. On 18 June 2026, the repository administrators informed us that the dataset record had been assigned a new URL, causing the previous web address to become inactive. The dataset itself has not been modified in any way, and the DOI cited in the manuscript has remained unchanged and continues to resolve correctly to the published dataset. We have updated the manuscript to include the current repository URL to ensure direct access for readers. The new access point is on the **line 486**: https://edatos.consorciomadrono.es/dataset.xhtml?persistentId=doi:10.21950/TK9BXK

- **Improve structure; "GENERAL INFORMATION" is quite long and "4. Description of the data set" better fits to "files"; "author" I would put together with "Contact". Also I recommend to use a common description format, ie. .json format.**

  Response: Thank you for your comments on the dataset's metadata. We have shortened the ***"GENERAL INFORMATION"*** section. The authors and contact details now appear together, and we have removed the sections containing no information, as well as moving the detailed description of the dataset to the ***"FILES"*** section. As for the suggested .json format, the *Readme-en.txt* file follows the standard template required by the institutional repository where the dataset is hosted; we will therefore keep it in the original .txt format to comply with the required standards.

- **"4. Description of the data set": Visually improve folder structure, for example by adding more indents for sub-points.**

  Response: Done.
  We have improved the structure of the detailed description of the folders and files in the *Readme-en.txt* file to make it easier to understand, by adding more indentation to the various sub-points. This is reflected in the ***"FILES"*** section.

- **Please state the meaning of FRY, consider the same for gBA and gsumFRP at first mention add Version date of data set.**

  Response: Done.

  FRY is the official name of the source dataset and does not correspond to an acronym defined in the original publication. Therefore, no expanded form is available. With regard to gBA and gsumFRP, we have included their definitions at the first occurrence of the terms, which is now in section ***"1. Methodology"***. There, they are defined as follows: *"A grid cell-month containing fire activity was defined as a Fire Cell-Month (FCM). For each FCM, **gBA** represents the total burned area, while **gsumFRP** represents the sum of all FRP observations recorded within the corresponding grid cell and month".*

- **"GEOGRAPHIC INFORMATION" → add resolution**

  Response: Done.

  We have included the resolution in section "***GEOGRAPHIC INFORMATION"***

  "1. Spatial coverage
  "Global - Coordinate Reference System (CRS): WGS84 (EPSG:4326)
  Spatial resolution: 0.25°"

- **"RELATED PUBLICATIONS" → add ESSD-publication.**

  Response: Done.

  We have included the publication relating to the preprint in the ***"RELATED PUBLICATIONS"*** section.

  "Solano-Romero, E., Segura-Garcia, C., Pettinari, M. L., Khairoun, A., Torres-Vázquez, M. Á., and Chuvieco, E.: A global database of extreme fire events from satellite data from 2003 to 2022, Earth Syst. Sci. Data Discuss. [preprint], https://doi.org/10.5194/essd-2026-236, in review, 2026".

- **I don't see the need for "Keywords" in the readme, as long as you can't search for them in a database. Maybe they could be used in the databases platform mask.**

Response: The "***Keywords"*** section is part of the metadata template required by the institutional repository and therefore we have to include it. In any case, these keywords also appear in the databases platform mask.

- **What is meant by "OTHERS"? 1. Data dictionary?**

  Response: We have removed the "OTHERS" section, as it did not contain any information.