RC3

General comments

The paper presents and update of GFED5 BA and wildfire emissions for daily monitoring of both variables based on VIIRS active fire information. The paper is well written and documented and the topic is very appropriate for the journal scope.

Major issues:

I have a couple of major issues and a few minor aspects.

My first concern relates to the modelling environment of GFED5NRT, which includes additional uncertainty in the original product. This uncertainty is not deeply analysed in the paper, which greatly limits its practical use. The new version should include this aspect. In the same line, since EFA scalars are derived from GFED5 BA, which is also modelled from HR datasets, the impact of errors distribution may be significant. The VNP BA products estimate similar BA as MODIS, therefore well below the GFED5 BA estimations. I think this new product should be based on direct comparison with those HR datasets used to derive the GFED5 estimations, whenever possible.

We thank the reviewer for highlighting the importance of a more explicit assessment of uncertainties associated with the GFED5NRT modelling framework. In response, we conducted two complementary lines of analysis to strengthen the manuscript.

First, as described in detail in our response to Reviewer 1, we substantially expanded the uncertainty analysis by directly comparing GFED5NRT with GFED5. These additions include regional evaluations of spatial agreement between GFED5 and GFED5NRT, extension of the analysis from burned area to fire carbon emissions to assess error propagation through the modelling chain, and grid-cell–level maps of temporal consistency to better characterize spatial variability in model performance.

Second, to address concerns about cross-validation, we expanded our regional evaluation to include comparisons with additional, higher-resolution fire datasets across multiple fire-prone regions, thereby providing a more direct assessment of the robustness of the EFA scaling approach. Please refer to our response to the relevant comment in this document for details.

Together, these analyses provide a more comprehensive and spatially explicit characterization of uncertainties arising from the GFED5NRT modelling framework and the underlying burned area estimation approach. We believe they substantially improve the transparency, robustness, and interpretability of the GFED5NRT dataset and directly address the concerns raised by the reviewer.

In addition, this modelling effort may benefit by using FRP instead of AF information, as the actual emissions are not only related to the number of fire events, but also to their intensity-severity.

We agree with the reviewer that FRP is closely linked to instantaneous combustion rates and has been widely used as a basis for near-real-time fire emission estimates in several existing products.

In the GFED5NRT framework, however, we adopt a two-step approach in which active fire observations are used to independently derive burned area and subsequently estimate emissions. In this context, we consider a binary active fire detection mask a more direct proxy for burned area occurrence, whereas FRP integrates information on both fire occurrence and intensity, which is influenced not only by burned area but also by fuel characteristics such as fuel load and moisture conditions.

In addition, the use of FRP introduces additional uncertainties associated with its retrieval, including sensitivity to background radiance estimation, atmospheric and smoke attenuation, sub-pixel fire heterogeneity, and potential sensor saturation under high-intensity fire conditions. Given these considerations, and to maintain consistency with the burned-area–based structure of GFED5, we use active fire counts rather than FRP in the current GFED5NRT implementation.

We agree that FRP-based approaches provide a valuable and complementary pathway for near-real-time emission estimation. An interesting direction for future work will be a systematic comparison between FRP-driven emission estimates and the current two-step active-fire-based approach to better understand their respective strengths and limitations. We incorporated this into the Conclusions section of the revised manuscript:

“Future versions of GFED5NRT could further reduce these uncertainties by improving dynamic effective fire area and fuel consumption estimates, updated land-cover information, and improved algorithms for constraining fire emissions estimates using fire radiative power observations”

It is not clear to me how the EFA and FC values of figure 3 were derived and why critical combinations of cover-biome were not considered (I assume this is the meaning of the white colors (but it is not indicated)? In any case, it seems odd that peats are not considered in the BONA or BOAS regions.

We thank the reviewer for pointing out these areas of ambiguity. We have updated the caption of Figure 3 in the revised manuscript to explicitly clarify these points.

Specifically, the white grid cells indicate regions and land-cover combinations where fire activity was historically absent or insufficient to calculate robust scaling statistics over the 2012–2022 period. Regarding boreal peats, the "Peat" classification in this specific aggregated framework refers to tropical peatlands (such as those in EQAS). In high-latitude regions like BONA and BOAS, peatland fires are grouped under the "BoreFor" (Boreal Forest) category, which encompasses boreal forests, sparse boreal forests, and tundra systems.

In the revised manuscript, we have made the following clarifications in the updated caption text.

“The Peat category refers only to tropical peatland burning and excludes boreal peatlands. White grid cells indicate region–land-cover combinations with insufficient or no fire activity over 2012–2022 to compute robust scaling statistics.”

Minor issues:

Line 121: "To reduce commission errors associated with the coarse spatial resolution of MODIS", I assume this is a spelling error, since MODIS MCD64 has much higher omission than commission errors.

Thank you for this comment. We agree that the dominant source of error in the MODIS MCD64 burned area product is omission, primarily because small fires are often undetected at the spatial resolution of the MODIS sensors. At the same time, the relatively coarse spatial resolution can also contribute to commission errors by mapping mixed pixels or overestimating the extent of burned areas in some cases. To better reflect both types of uncertainty, we revised the text by changing "commission errors" to "omission and commission errors."

Line 150: thereby improving fire mapping, fire behavior characterization, and applications in disaster response and land management." References are needed here.

We added the VIIRS active fire reference Schroeder et al. (2024) here in the revised manuscript.

Line 163: "we selected the NRT fire image products (VNP14IMG_NRT and VJ114IMG_NRT), rather than the NRT fire location products", not clear what products you refer to, and what are the processing differences between these two options.

The primary distinction lies in the data format and level of contextual information: the NRT fire location products are text/vector summaries providing only the coordinates and attributes of detected hotspots, whereas the NRT fire image products are full 2D swath raster layers containing the complete active fire mask (including non-fire, clear land, water, and cloud pixels). Access to the full raster geometry is required to calculate pixel dimensions and perform scan-angle dependencies. We have a short description of this in section 2.3.3 of the original manuscript:

“*Scan angle information is only available in the science-quality product (VNP14IMGML and VJ114IMGML) and is absent in the NRT fire location products (VNP14IMGDL_NRT, VJ114IMGDL_NRT). To address this limitation, we used upstream two-dimensional NRT imagery products (VNP14IMG_NRT, VJ114IMG_NRT) to generate daily fire location files in a VNP14IMGDL_NRT-like format, incorporating both sample numbers and key fire attributes. These additional files were then used to perform viewing geometry correction and normalize fire counts.*”

In order to better clarify this distinction, we add a brief sentence in the Data section (after original Line 163):

"As discussed below (Sect. 2.3.3), we selected the NRT fire image products (VNP14IMG_NRT and VJ114IMG_NRT), rather than the NRT fire location products (VNP14IMGDL_NRT and VJ114IMGDL_NRT), because the image products retain the full 2D swath raster fire mask. This geometric context is required to perform viewing-angle corrections, including calculating pixel size variations away from nadir."

Figures 4 and 7 have basically the same information. If you keep the latter, include at least the uncertainty of the estimations, which is now not covered.

Thank you for this suggestion. We agree that uncertainty representation is an important aspect of result interpretation; however, we would like to clarify that Figures 4 and 7 serve distinct and complementary purposes.

The primary purpose of Figure 4 is to evaluate the performance of GFED5NRT by quantifying its agreement with GFED5 in reproducing temporal variability of burned area across regions during the overlap period. In contrast, Figure 7 presents the final merged dataset, combining GFED5 and GFED5NRT to provide the best available continuous time series for scientific use. Thus, Figure 4 is intended as a validation of GFED5NRT, whereas Figure 7 is intended as a synthesis product for application-oriented use. We modified the caption of Figure 7 to emphasize it represents combined time series:

"Figure 7. Combined annual time series of regionally summed (a) burned area (Mha yr-1) and (b) fire emissions (Tg C yr-1), integrating three GFED5 products: the core period (2002-2022, orange), the pre-MODIS period (1997-2001, gray), and the GFED5NRT product (2023-2024, red)."

Regarding the inclusion of uncertainty in Figure 7, we agree that uncertainty quantification would be desirable. As noted in our responses to earlier comments, relative uncertainties in regional annual burned area and emissions can be estimated from the GFED5–GFED5NRT comparison. However, a full formal uncertainty propagation for the merged product is not feasible, as uncertainties in GFED5 itself are not explicitly quantified and arise from multiple upstream sources, including heterogeneous input datasets, model structure, and parameterizations, many of which lack well-defined uncertainty bounds.

For this reason, and to avoid implying a level of precision that cannot be rigorously supported, we have chosen not to include explicit uncertainty ranges in Figure 7. We instead address uncertainty characterization through the expanded analyses presented in the revised manuscript and in the supplementary material.

You used as a cross-comparison data from Canada and Brazil (although Mapbiomas does not include daily estimations, but I monthly with a high uncertainty as Landsat has low temporal resolution). Why not US and European data? It may be convenient to take a look to the compilation of BA datasets published by Gincheva et al. (2024).

Gincheva, A., Pausas, J.G., Edwards, A., Provenzale, A., Cerdà, A., Hanes, C., Royé, D., Chuvieco, E., Mouillot, F., Vissio, G., Rodrigo, J., Bedía, J., Abatzoglou, J.T., Senciales González, J.M., Short, K.C., Baudena, M., Llasat, M.C., Magnani, M., Boer, M.M., González, M.E., Torres-Vázquez, M.Á., Fiorucci, P., Jacklyn, P., Libonati, R., Trigo, R.M., Herrera, S., Jerez, S., Wang, X. y Turco, M. (2024). A monthly gridded burned area database of national wildland fire data. Scientific Data, 11, 352.

We thank the reviewer for this constructive suggestion and the literature recommendation. As suggested, we have expanded our regional validation (now updated in Fig. S7) to include independent datasets across the US, Europe, and Australia. Specifically, we incorporated MTBS and FPA_FOD for the US, EFFIS for Europe, and ONFIRE for Australia. While these regional datasets have varying temporal coverage—often not fully covering recent years since 2023—and carry their own caveats, they offer valuable independent baselines for cross-validating our historical GFED and GFED5NRT estimates.

We have added the following data description text for MTBS, FPA_FOD, EFFIS, and ONFIRE to Section 2.6 of the methods section..

"For the US, we utilized the Monitoring Trends in Burn Severity (MTBS; https://www.mtbs.gov/) dataset, which uses Landsat imagery to provide comprehensive satellite-derived burned area data for large fire events exceeding specific regional size thresholds, alongside the Fire Program Analysis fire-occurrence database (FPA_FOD; https://doi.org/10.2737/RDS-2013-0009.6), which compiles official federal, state, and local government fire reports to offer a detailed spatial inventory of wildfire activity. For Europe, we evaluated performance against the European Forest Fire Information System (EFFIS; https://forest-fire.emergency.copernicus.eu/), which aggregates harmonized monthly burned area statistics reported by member countries and satellite-derived burnt area mapping. Finally, for Australia, we relied on the regional data compiled within the ONFIRE database (https://zenodo.org/record/8289245), which harmonizes fire perimeters and statistical data sourced from individual state and territory fire management agencies into a common 1°×1° monthly gridded burned-area product."

We have also added the results from these comparisons in the Results section as follows:

"Compared with regional burned area datasets derived from high-resolution satellite observations and fire records, annual burned area estimates from GFED5 and GFED5NRT are generally of comparable magnitude and reproduce similar interannual variability across regions (Fig. S7). These reference datasets differ substantially in mapping methodology and coverage: some exclude small burned patches, others omit cropland or non-forest burning, which likely explain the tendency for GFED5 and GFED5NRT to report higher annual burned area, most notably in Europe, where EFFIS includes only fires larger than 30 ha that are at least partially forested. In Canada, GFED5 and GFED5NRT estimates are slightly higher than NBAC during extreme fire years (e.g., 2023 and 2024), likely because NBAC explicitly delineates small unburned islands that may not be resolved at coarser spatial resolutions. In Brazil, GFED5 and GFED5NRT totals generally agree with the INPE AQ1km product, but are substantially higher than MapBiomas, reflecting well-documented methodological differences among these datasets. In the US, MTBS's minimum size threshold (500–1,000 acres) and FPA_FOD's exclusion

of prescribed and controlled burns likely explain why GFED5 and GFED5NRT run consistently higher than these reference datasets. In Australia, GFED5 and GFED5NRT closely track ONFIRE in magnitude and timing of major fire years (e.g., 2019–2020 "Black Summer").”

Fig. R7. Comparison of annual burned area from GFED5 and GFED5NRT with independent regional datasets for 2002-2024 over (a) Canada, (b) Brazil, (c) United States, (d) Europe, and (e) Australia. For GFED5NRT, the combined SNPP + NOAA-20 product is shown for 2023-2024, and the SNPP-only product for 2012-2022. Canadian comparisons include the Canadian National Fire Database (CNFDB; agency-reported fire perimeters), the National Burned Area Composite (NBAC; Landsat-based burned area), and two independent 2023 estimates (NRCan_2023 and TIIC_2023). Brazilian comparisons include the INPE AQ1km product (MODIS-based burned area) and MapBiomas (Landsat-based). US comparisons include MTBS and FPA_FOD. Comparisons between Europe and Australia include National Wildfire Data (ONFIRE). Crop-related burned area in GFED5 and GFED5NRT were excluded for Canada, the US, and Europe to ensure consistency with external datasets.