Author Responses to Reviewer 1

General overview

We thank the reviewer for this constructive feedback. Our work is fully based on remote-sensing analysis, which naturally limits the investigation of species-level vegetation or socio-anthropological aspects. The study aims to identify and quantify drivers of fire size, rather than reviewing fire ecology or analyzing drivers of fire occurrence, which would require interdisciplinary field, policy, and social data across three countries.
We acknowledge that the paper is meteorology-centered because weather largely determines when fires expand, while fuels and landscape structure control how far they spread. This complements rather than replaces ecological or human-focused studies on Chaco fires.
We will revise the title and abstract to better reflect this scope.

1. Vegetation, landscape, and human context

Reviewer comment:
Expected more information on vegetation types, landscape heterogeneity, and historical human use of fire.

Author response:
We will expand the Introduction and Discussion to include brief contextual information on **vegetation structure, landscape diversity, and human fire use**, with targeted references (Bravo et al.; Vidal-Riveros et al. 2023; our previous works, including San Martin's PhD thesis). However, a detailed biological or historical reconstruction lies **beyond the scope** of a remote-sensing study. These limits will be explicitly clarified, with references to existing comprehensive reviews.

2. FRY / FireCCI provenance

Reviewer comment:
FireCCI51 is outdated; use or compare it with FireCCIv.5.1.1cds. Only v5.1.1cds should be used.

Author response:
Our analysis uses **FRY v2.0**, which was generated from **FireCCI51** distributed on the ESA CCI portal. After a minor processing issue affecting Jan 2018 and Oct–Dec 2019 was identified, ESA CCI updated FireCCI51 in place (same version label) while Copernicus CDS published an equivalent corrected stream as v5.1.1cds for traceability. Consequently, **FireCCI51 downloaded from ESA CCI's catalog is equivalent to FireCCI v5.1.1cds (Copernicus Data Store)**; **FRY v2.0**

was computed from the corrected CCI dataset, so our work already relies on the current, corrected inputs.

This has been confirmed in writing by **María Lucrecia Pettinari (ESA FireCCI team)** and **Florent Mouillot (FRY developer and co-author of this manuscript)**. M.L. Pettinari clarified (email, 15 Oct 2025) that CCI's FireCCI51 and CDS's FireCCI v5.1.1cds are the same content under different versioning policies, and that FireCCI51 used for FRY was already corrected. F. Mouillot advised citing FireCCI51 (ESA CCI) as the official product name and DOI. We will add a concise provenance note in Methods explaining this equivalence and avoiding future confusion between the CCI and CDS labels. For transparency, we have attached the paraphrased email confirmation at the end of this document.

ESA CCI Fire data: https://climate.esa.int/en/projects/fire/

FireCCI51 from ESA CCI's catalog:
https://catalogue.ceda.ac.uk/uuid/3628cb2fdba443588155e15dee8e5352/

3. Fire-size classification

Reviewer comment:
Define and justify megafire thresholds; agencies use different scales: "why ~10,000 ha is selected instead of a larger number (e.g., 40,000+ ha)".

Author response:
Our classification of **Megafires (100–1000 km² or 10,000–100,000 ha)** and **Gigafires (1000–10,000 km² or 100,000–1,000,000 ha**) follows the standardized terminology proposed by Linley et al. (2022). For smaller fires, we used a classification adapted to the fire sizes we found in the Gran Chaco.

Linley et al. (2022) established globally comparable definitions for large-fire categories to promote clarity across studies and avoid inconsistencies with regional or agency-specific thresholds such as 40,000 ha.

As stated in Linley et al. (2022):

> *"To overcome ambiguity, we suggest a definition of megafire as fires > 10,000 ha arising from single or multiple related ignition events. We introduce two additional terms — gigafire (> 100 000 ha) and terafire (> 1 000 000 ha) — for fires of an even larger scale."*

This standardized framework ensures terminological consistency and facilitates direct comparison with global fire-size research. We already specify this classification and cite Linley et al. (2022) in the Methods (line 194); in the revised version, we will make the reference more explicit and emphasize that our categories follow this scientifically defined scale.

4. Human drivers and datasets

Reviewer comment:
The anthropogenic dimension is weak; consider more analysis of human–fire interactions.

Author response:
We acknowledge this and will review Section 4.5 to improve clarity.
Besides, we recall that the changes made in the title of the paper will help readers not expecting a thorough analysis of human-fire interactions.

Additionally, we will **incorporate a more detailed road-network dataset to improve the calculation of road density within the fire polygons**, which is a clear and consistent proxy for accessibility and human influence measurable by remote sensing.
The dataset previously used likely under-represented informal or unmapped tracks, particularly in areas of private agricultural expansion or unregulated clearing.

5. Figure 3 and 2020/21 peak

Reviewer comment:
Improve readability and explain the 2020–2021 peaks.

Author response:
We will **rebuild Figure 3** (fonts, labels, scaling).
We may briefly explore additional potential explanations for the **2020 fire peak; however, our focus remains on fire size, rather than** fire occurrence or ignition causes. The years 2020 and 2021 were special from a sociological perspective, given the COVID-19 outbreak. It is possible to link some of the ignitions to a greater lack of governmental control, and the final sizes to a lack of suppression. Still, we believe that, given the strong La Niña event and the unprecedented drought that affected the region during that period, the causes of the **larger** fires were primarily meteorological.

6. Pearson correlation and FWI anomalies

Reviewer comment:

Clarify the use of Pearson correlation with skewed data and the meaning of FWI anomalies; why not use FWI95?

Author response:

We appreciate this observation and clarify that our correlations are performed on monthly anomalies of FWI and burned area (time series shown in Fig. A7 of the manuscript), not on the raw values. Only pixels with more than three fire-active months (burned area > 0) are included; those with fewer events or non-significant correlations are represented by dots in the maps and excluded from the statistics printed over the figures. In our revised manuscript, we will modify the filter to four fire-active months to improve robustness and avoid including pixels with too skewed burned area anomalies.

FWI anomalies are computed as daily deviations from the 2001–2020 climatology and then aggregated monthly. This definition is already described in the Methods (line 188), and we will make it clearer in the revised text. As shown in **Fig. 1 below**, the anomalies of burned area and fire counts are substantially less skewed than their raw values, supporting the validity of the correlation analysis.

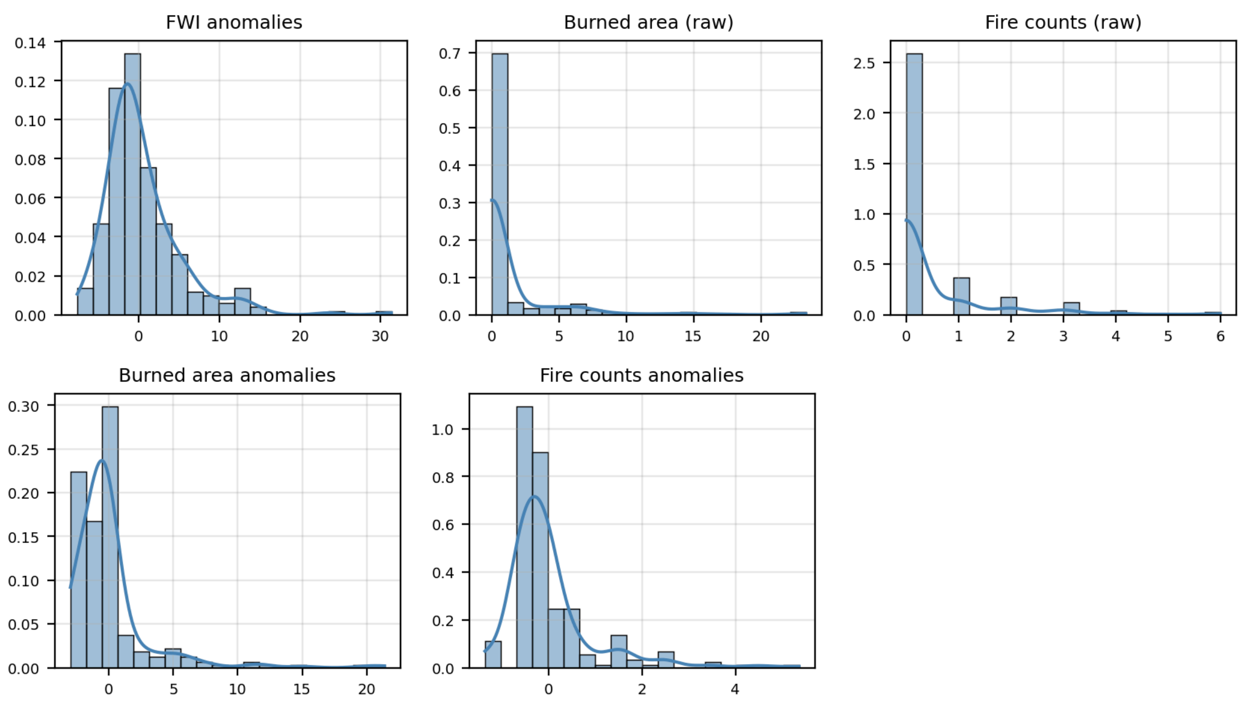

Fig. 1. Histograms of FWI anomalies, Burned area (raw), Fire counts (raw), Burned area anomalies and fire counts anomalies for a particular pixel (coords: lat: -26.30º; lon: -56.7º).

Regarding the statistical method, Pearson's r does not strictly require normally distributed variables but assumes linearity and homoscedasticity. Because some burned area distributions may remain right-skewed, we computed Spearman's rank correlations, which are non-parametric and robust to non-normality and outliers, following the reviewer's recommendation. We will include these updated figures in the revised manuscript.

The comparison (**Figures 2–3 below**) reveals that both approaches produce consistent spatial patterns across the Chaco: regions with positive correlations in the Wet and Dry seasons are similar in both cases. However, some differences in magnitude appear, particularly in transitional areas with weaker signal strength or more non-linear fire–weather responses (e.g., central Wet Chaco and parts of the Dry Chaco). These localized differences are expected because Spearman's ϱ downweights outliers and is less sensitive to extreme values than Pearson's r. Importantly, the persistence of the main spatial signal under both formulations demonstrates the robustness of our correlation patterns to methodological choice.

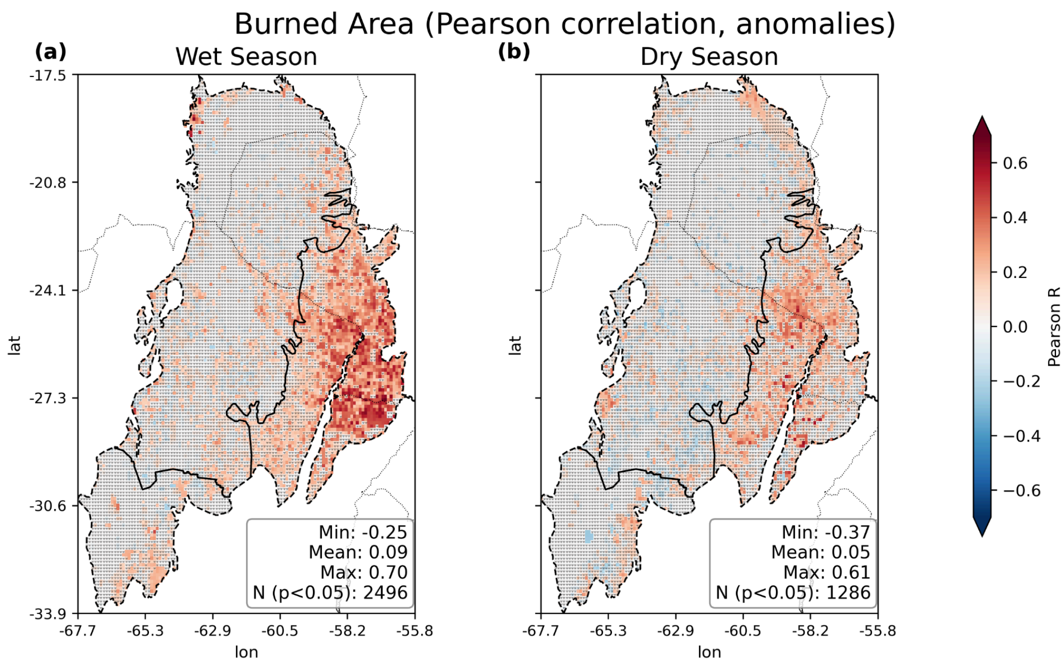

Fig. 2. Spatial correlation between monthly FWI anomalies and burned-area anomalies (2001–2022) computed using Pearson's r for the Wet and Dry seasons. Only pixels with at least four fire-active months and significant correlations ($p < 0.05$) are shown.

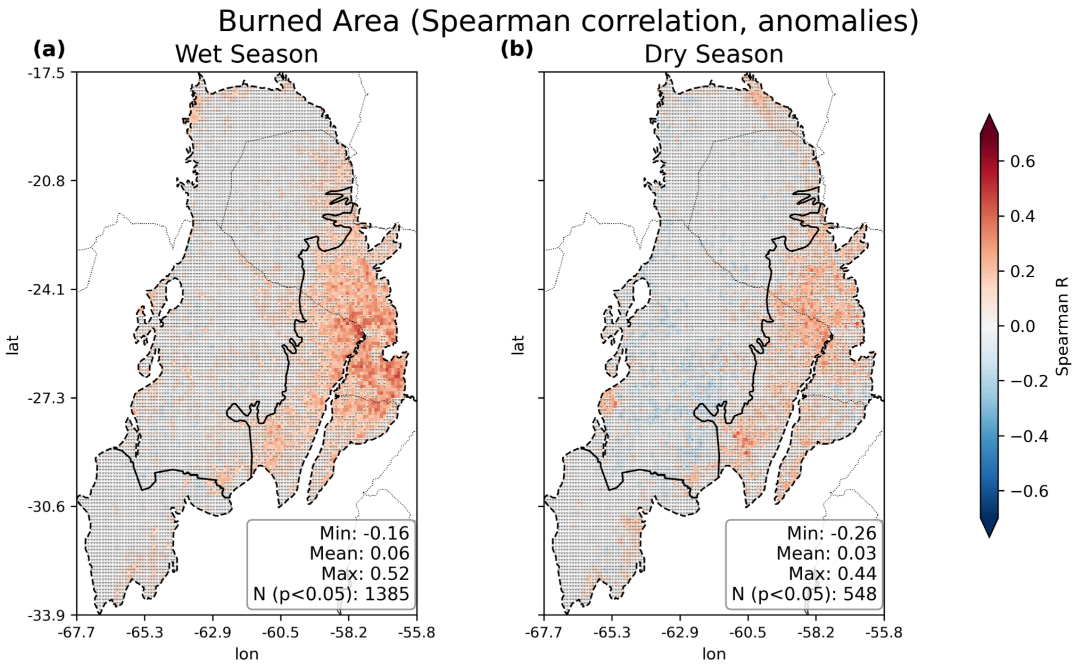

Fig. 3. Spatial correlation between monthly FWI anomalies and burned-area anomalies (2001–2022) computed using Spearman's r for the Wet and Dry seasons. Only pixels with at least four fire-active months and significant correlations ($p < 0.05$) are shown.

Finally, we emphasize that using pixel-level anomalies instead of a fixed FWI95 threshold allows each location to be evaluated relative to its own climatology, providing a more spatially consistent and locally meaningful measure of fire–weather relationships across the Chaco.

7. DEM and topography

Reviewer comment:
Add DEM and terrain context; discuss vegetation–topography–fire relations.

Author response:
A **DEM (SRTM)** is already included in **Figure 1**, as stated in the **Methods (lines 151–154)**: "Topography was derived from the Shuttle Radar Topography Mission (SRTM) digital elevation model at 30 m resolution (https://srtm.csi.cgiar.org, accessed 26 May 2025) (...)"
We will make this clearer in the text, but we will not add the DEM to every map, as this would obscure other layers.

8. Minor edits and terminology

Reviewer comment:
Various style and clarity issues.

Author response:
We will:
– Revise grammar errors and phrasing to "**short-term meteorological anomalies and long-term environmental gradients**";

Summary of planned revisions

– Clarify **FRY/FireCCI** provenance (with consultation of FRY's developer and co-author, Florent Mouillot, and FireCCI51 developer, Lucrecia Pettinari).
– Reaffirm and explain **Linley** fire-size classes (line 194).
– Add concise **vegetation, landscape, and human-use context** with references.
– Assess a **more detailed road dataset** to improve road-density estimation within fire polygons.
– Rebuild **Figure 3** for clarity.
– Clarify **FWI anomalies** (line 188) and justify **Pearson correlation**; add **Spearman** test.
– Emphasize that **pixel-level anomalies** are spatially consistent, unlike other metrics (e.g., FWI95).
– Clarify that **DEM** (SRTM) is already included in **Figure 1**.
– Revise **title/abstract** to better reflect the meteorological focus.

We thank the reviewer once again for their thoughtful and detailed evaluation. Their comments help us clarify the scope, strengthen methodological transparency, and improve the overall structure and readability of the manuscript.