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Title
A high spatial resolution daily fire perimeter progression dataset for wildfires in the Western United States: 2020-2024

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Abstract
The dataset is a spatially and temporally organized curated subset of National Infrared Operations Program real-time high-resolution fire perimeter acquisitions for the Western United States from 2020 to 2024. The U.S. Forest Service's National Infrared Operations is an ordered resource that flies only when requested and prioritized, and which tracks and documents wildfire progression over time. Through a structured data retrieval, consolidation, and metadata curation process, the dataset organizes fire perimeters and associated attributes to facilitate the temporal and spatial reconstruction of fire progression. The resulting shapefile integrates multiple data sources, ensuring spatial standardization to improve interoperability. This resource may be applied in various fields, including fire behavior modeling, fire risk analysis, ecological impact assessment, and resource management. It offers a transparent, replicable workflow and encourages reuse by providing supporting code, enabling researchers, land managers, and policymakers to incorporate these fire perimeters into broader analyses and decision-making processes.

Background & Summary
The National Infrared Operations (NIROPS) program, operated by the U.S. Forest Service, provides the most detailed and timely infrared-based wildfire perimeters available to the public[1]. The Forest Service has been collecting airborne infrared imagery for wildfire detection and mapping since 1969, well before space-based detection methods existed[1–3]. While orbital sensors such as Moderate Resolution Imaging Spectroradiometer (MODIS) and Visible Infrared Imaging Radiometer Suite (VIIRS) now offer global fire-detection coverage, they still cannot match the high spatial precision and rapid turnaround that NIROPS delivers for tactical fire management. Today, NIROPS mapping is an ordered resource, with data collection initiated through official requests from incident management teams, prioritizing active and high-complexity fires based on operational needs[4]. These perimeters are interpreted by trained infrared specialists who digitize fire boundaries from orthorectified thermal imagery collected during aerial overflights. These overflights typically occur overnight, with finalized data products delivered to incident management teams within 3 to 6 hours of the flight to provide near-real-time views of the fire position before morning briefings. Daily wildfire perimeters provide spatial context for identifying the extent of burned areas, guiding response, and informing resource allocation decisions.

Historical NIROPS data have proven valuable across a range of wildfire science applications. Researchers have used NIROPS fire perimeters to validate coarser-resolution satellite products, including VIIRS[5,6] and combined VIIRS and Geostationary Operational Environmental Satellites (GOES) burned-area estimates[7], and to benchmark newly developed hourly GOES perimeter retrievals[8]. Daily or sub-daily NIROPS snapshots have supported rapid-response perimeter-growth algorithms and machine-learning estimates of fire-arrival time from MODIS and VIIRS detections[9]. MODIS and VIIRS active-fire records themselves have been compared against NIROPS-derived perimeters to evaluate progression-mapping accuracy[10,11].

Beyond validation, NIROPS data have been assimilated directly into coupled fire–atmosphere models[12,13] and high-resolution Coupled Atmosphere Wildland Fire Environment (CAWFE) reconstructions of the 2014 King and 2012 High Park fires[14,15].They also enabled novel observational approaches, such as verifying radar-derived perimeters[16] and quantifying environmental controls on spotting distance[17]. Additionally, standardized NIROPS maps have supported assessments of fuel-treatment effectiveness on burn severity when integrated with remote-sensing and fire-weather datasets[18]. Collectively, these applications illustrate how NIROPS perimeter archives provide a high-spatial resolution reference framework that supports validation, modeling, and operational wildfire research.

Despite the value of NIROPS data for capturing high-resolution fire perimeters, it suffers from several shortcomings that have limited its utility as a data source. Specific drawbacks of the raw dataset include non-homogeneity and inconsistency of data reporting across and sometimes within each Forest Service Region, missing labels and mislabels of the events, broken and fragmented shapefiles including shape errors, geometrical inconsistency, inconsistent fire growth perimeters, geolocation inaccuracies, and overall lack of standardization or quality assurance protocols between each Forest Service Region. Because it was never intended as a research or model-training data archive, there has been an effort to clean and homogenize publicly available data. NIROPS daily perimeters available from the US National Interagency Fire Center (NIFC) are stored as individual daily shapefiles, limiting potential research and training applications. This dataset addresses that gap by systematically compiling and standardizing valid NIROPS-derived fire perimeter data from 2020 to 2024. By providing a consistent geospatial format with harmonized temporal and spatial metadata, we aim to make these data more accessible for research, management, and operational needs.

The compiled dataset provides a high-resolution view of fire progression across hundreds of fire events in the western conterminous United States. Its size and spatial detail make it particularly useful for large-scale analyses, including retrospective studies of fire behavior, suppression effectiveness, and post-fire landscape impacts. The dataset is also well-suited for training and validating machine learning models to predict fire spread, identify control opportunities, or assess treatment outcomes. By improving access to standardized, event-level perimeter data, this work supports broader efforts to advance wildfire science and inform evidence-based fire management strategies.

Methods

Data Acquisition and Study Region. Most of the Data presented here are publicly accessible and were obtained from an FTP site hosted by the US National Interagency Fire Center (accessible from https://ftp.wildfire.gov/public/incident_specific_data/). As of May 4, 2026, data access now requires creation of a Login.gov account for all folders under the Authenticated Access area. In addition, the path to these folders has changed from "public" to "protected". For example, https://ftp.wildfire.gov/public/incident_specific_data is now https://ftp.wildfire.gov/protected/incident_specific_data. In addition to NIROPS data, we include official internal records from the interagency Wildland Fire Decision Support System (WFDSS), maintained by the USDA Forest Service Wildland Fire Research, Development, and Application program. Records were approved for publication by WFDSS data stewards and can be requested in the future from the contacts listed on the WFDSS home (https://wfdss.firenet.gov/help/Content/Home.htm). Direct WFDSS access is limited to authorized users from the USDA Forest Service and authorized partners. We include only infrared fire perimeters from WFDSS that were equivalent to the NIROPS dataset but not accounted for in the publicly available NIROPs dataset. The NIROPs FTP site and WFDSS are organized by US Forest Service Region as highlighted in Figure 1, that are labeled as ‘n_rockies’ as Northern Rockies (Region 1), ‘rocky_mtn’ as Rocky Mountain (Region 2), ‘southwest’ as South Western Region (Region 3), ‘g_basin’ as Great Basin (Region 4), ‘pacific_nw’ representing Pacific Northwest (Region 6). Region 5, representing the Californian region, is subdivided into Northern California (labeled as ‘n_calif’) and Southern California (labeled as 's_calif’). Northern California includes the Sierra Nevada, the Klamath Mountains, and coastal redwood forests, which generally have cooler, wetter climates. Southern California includes the Transverse Range and part of the Mojave Desert, which typically has dry, arid climates. Region 5 also includes the State of Hawaii; however, it is not included in the study due to a lack of sufficient data.

The Northern Rockies (Region 1) encompasses 25 million acres in five states. These included the 12 national forests located in northeastern Washington, northern Idaho, and Montana, as well as a national grassland in North Dakota and northwestern South Dakota. The Rocky Mountain (Region 2) includes 11 national forests and grasslands in Colorado, Wyoming, South Dakota, Nebraska, and Kansas. The Southwest (Region 3) covers 11 national forests in Arizona and New Mexico and two national grasslands in New Mexico, Texas, and Oklahoma. The Great Basin (Region 4) covers 13 National Forests and one National Grassland within Utah, Nevada, western Wyoming, southern Idaho, and a small portion of California. The Pacific Northwest (Region 6) mainly covers the States of Washington and Oregon, which include 16 National Forests, National Scenic Areas, a National Grassland, and National Volcanic Monuments. We include the original forest service region and descriptor for each NIROPS or WFDSS record.

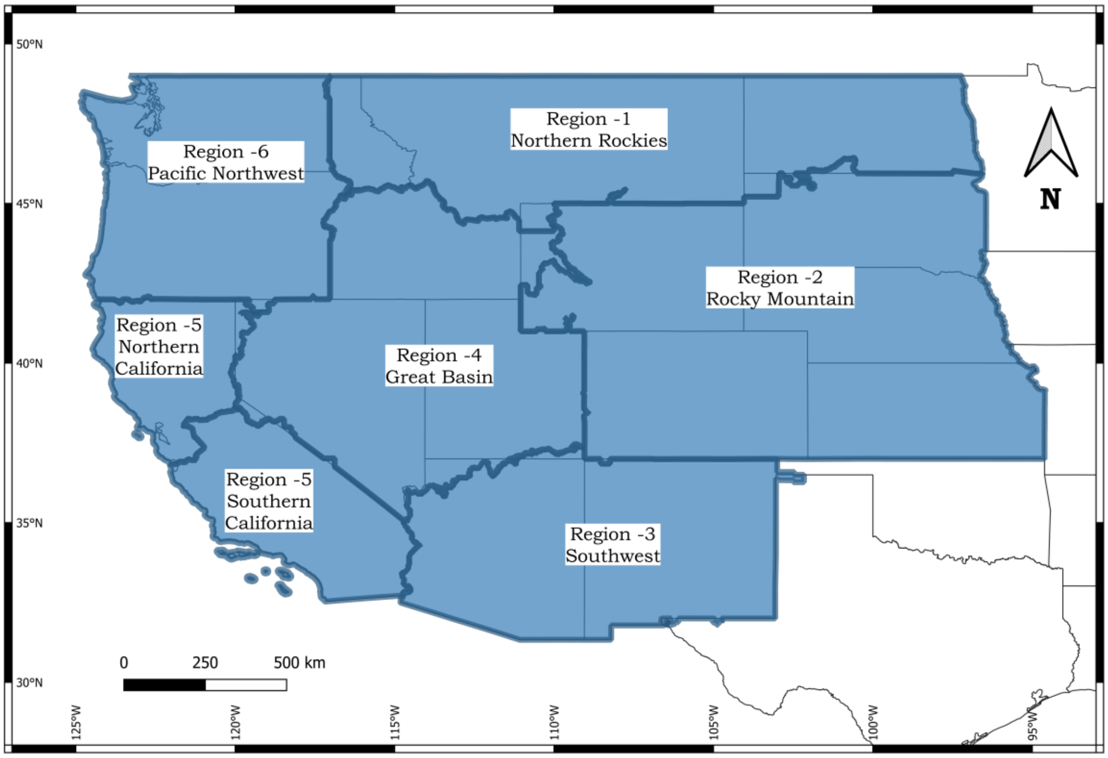

Figure 1. U.S. Forest Service administrative Regions 1–6, representing the western United States (excluding Hawaii).

In the NIROPs FTP directories, fire perimeter progression spatial data is primarily stored in folders labeled as 'IR' or 'GIS', though in some cases it may also be located in other subdirectories. This data is generated by Infrared Interpreters (IRINs), who interpret thermal imagery from NIROPS sensors to delineate fire perimeters as polygons. Since these data were generated by multiple IRINs across different agencies, the files were provided in a variety of formats, including shapefiles, KMLs, KMZs, and Esri geodatabase files. Our role was limited to organizing and checking the temporal and spatial consistency of fire perimeter records and filtering out erroneous or incomplete records in the existing database without modifying the original digitized files or verifying the accuracy of the digitizing work itself, as the original NIROPS source imagery is not publicly available, and access requires clearance. We developed an automated Python workflow using requests and BeautifulSoup[19,20] to parse the NIFC FTP directory, identify and download relevant IR folders for 2020–2024 fires, and preserve the original structure. ZIP files were decompressed and standardized shapefiles extracted to support consistent local organization.

Selection Criteria. We did not process every fire incident available on the NIROPS FTP server or within the WFDSS database. Instead, we applied selection criteria to identify incidents that contained enough temporal information to support meaningful analysis of fire behavior. Because understanding growth requires more than isolated perimeter snapshots, we limited our dataset to fires with at least three days of perimeter data, including at least one pair of consecutive daily acquisitions. This ensures that the DateUTC values capture day-to-day change, as NIROPS imagery is often collected roughly one day apart when operationally feasible. Many incidents on the FTP site and in the WFDSS database contain only one or two perimeter files or lack consecutive days, due to operational constraints such as aircraft availability, weather, and the timing of infrared missions. Our final dataset, therefore, emphasizes multi-day sequences that document fire progression. It does not necessarily include the ignition or final perimeters for each event and should be viewed as an ordered resource for analyzing fire growth rather than a complete record of all daily perimeters.

Data Consolidation and Standardization. To unify individual perimeter records into a standardized dataset, we consolidated individually sourced fire progression files from multiple events and formats. Data interpreters carefully reviewed and organized the downloaded files, manually adding metadata and resolving inconsistencies in reporting formats and naming conventions. Particular attention was given to each record's temporal and spatial components by assigning consistent timestamps as provided in the metadata files and validating geometries to ensure that fire progression is accurately represented and to identify features that may be inconsistent with expected patterns of wildfire growth, such as major reductions in perimeter extent, mixed perimeters from unrelated events, or the unexpected appearance and disappearance of fire boundaries.

To standardize the temporal component of the dataset, data technicians assigned consistent, interpretable timestamps to all records. For instance, incident maps, such as the one illustrated in Figure 2, were referenced to determine imagery collection dates, times, and UTM zones, providing a reliable basis for validating daily perimeter information. NIROPS data lacks a strict reporting standard. Therefore, collection times often appeared as attributes or were embedded within file names, necessitating careful cross-referencing of multiple data sources to assign timestamps. The derived 'UTC' attribute provides an approximate estimate of the imagery collection time in Coordinated Universal Time (UTC) zone. These timestamps offer a reasonable proxy for when the imagery was acquired, recognizing that data is collected throughout an aircraft flight rather than at a single point in time.

Similarly, spatial standardization involved careful review and processing of geometry to ensure uniformity and accuracy across all perimeter polygons. To ensure data quality and consistency, ambiguities such as incomplete attributes or inconsistent metadata were resolved using supplementary FTP information, including operational planning maps and derived products. Geometries underwent processing to correct topological errors (e.g., invalid polygons, self-intersections) introduced during digitization. In cases where these issues were detected, a zero-distance buffer operation was applied as a standard geometric repair method to address minor gaps or overlaps along polygon boundaries without altering their overall shape or location. Geometries that could not be reliably corrected were excluded from the dataset to preserve the overall accuracy of the final product. In some cases, perimeter files contained multiple incidents grouped together, likely resulting from simultaneous infrared imagery collection over nearby fires. When this occurred, individual incidents were separated, and if they met our selection criteria, they were processed independently and retained; otherwise, they were excluded during the data refinement. Although NIROPS interpreters sometimes record intense or scattered heat signatures, this dataset focuses exclusively on the main fire perimeters. Future efforts could incorporate these additional heat indicators to provide a more detailed representation of fire behavior and progression.

After standardization, daily fire perimeters for each event were compiled into a single shapefile, with each record organized by its collection date and time. If a timestamp was missing from a record, it was imputed with a local time of 21:00 hr. This value was selected because it represents the mode (most frequent observation) of the flight times, and it closely aligns with the median (20:00 hr) observed in the timestamps of other NIROPs flights. Timestamps were converted to UTC to ensure consistency across different time zones. To promote interoperability with other geospatial datasets, all geometries were reprojected to a standard coordinate reference system (WGS 84, EPSG:4326). These steps ensure that the dataset is both temporally aligned and spatially consistent.

Each record in the final dataset includes an attribute called 'Inc Number' and 'Inc Name', which reference the official National Unit Identifiers as outlined by the U.S. National Interagency Fire Center[21]. These identifiers are widely used to specify the dispatch center or administrative unit responsible for a given incident, ensuring consistent labeling across multiple agencies. Including national unit identifiers within each fire perimeter record provides a standardized reference for incident tracking and facilitates integration with other wildfire-related datasets. By aligning each record with its corresponding National Unit Identifier, we were able to cross-reference and obtain Integrated Reporting of Wildland Fire Information (IRWIN) IDs for incidents, linking spatial fire progression data to official incident reporting records.

In some cases, a large fire complex is divided into smaller sub-incidents for operational or processing purposes. The 'Incident_C' attribute serves as this finer-scale identifier, allowing differentiation of individual components within a larger complex that share the same 'Inc Number'. For example, the complex named South Fork Complex contains two distinct 'Incident_C' records (CA-SHF-001004_Pilot and CA-SHF-001004_ThreeNine) both associated with the same overarching identifier (CA-SHF-001004) but separated at the 'Incident_C' level to represent distinct sub-incidents within the larger event.

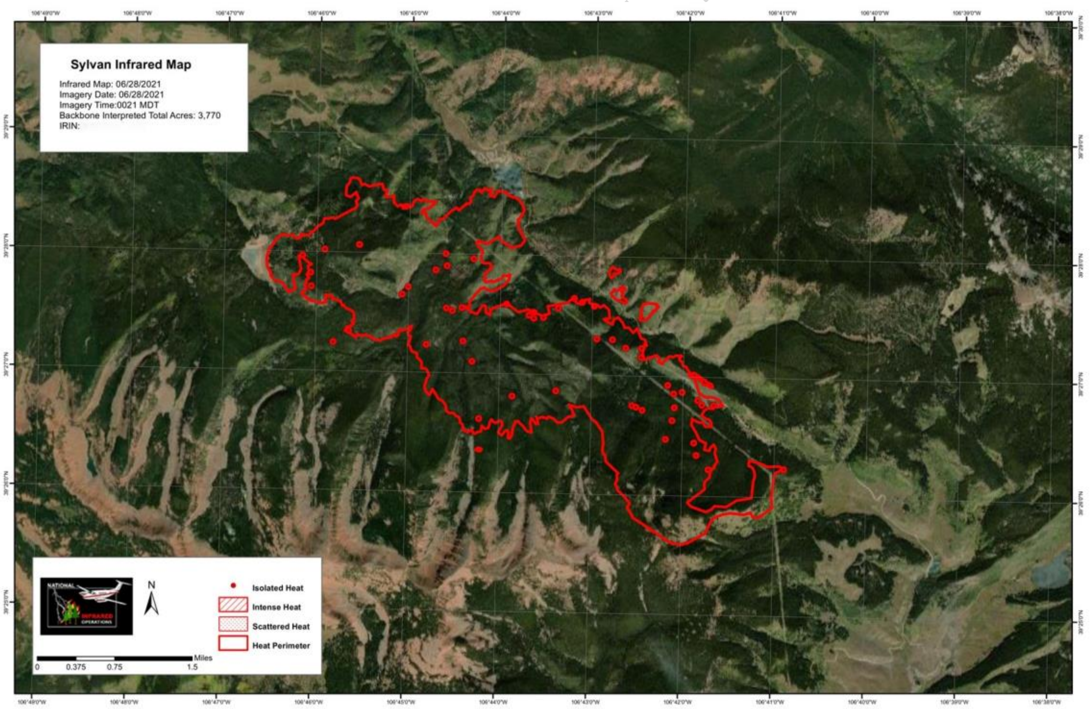

Figure 2. Example of an incident map used to verify imagery collection details and standardize metadata.

Data Records

The complete archive is deposited in Mendeley Data[23] under the record “High-Resolution Wildfire Perimeter Dataset from National Infrared Operations: 2020–2024” (https://doi.org/10.17632/95rj5d379g.1). The record begins with a single ESRI shapefile directory named

NIROPS_2020_2024_R1_R6. This directory contains the five companion files customary for an ESRI dataset (.shp, .shx, .dbf, .prj, and .cpg) and holds 12,705 perimeter snapshots representing 737 separate incidents. Each feature has geometry stored in geographic coordinates (WGS 84, EPSG 4326) and a fully standardized attribute schema that includes the incident identifier ('Incident_C'), a 'DateUTC' field in MM/DD/YYYY format, a 'UTC' field with the full timestamp (YYYY-MM-DD HH:MM:SS), and calculated fire perimeter area in acres ('Acres'). In addition to these fields, the dataset also retains IRWINID, Inc_Name, and Inc_Number attributes, as previously described, which preserve the original incident identifiers and naming conventions. These fields facilitate direct linkage to IRWIN and agency incident records and enable users to cross-walk NIROPS perimeters to other operational and archival datasets.

Two supplementary folders accompany the shapefile. Supplementary_Maps contains a quick-look PNG for every incident, giving a visual impression of the spatial footprint without the need for GIS software. Area_Progression_TimeSeries provides another PNG for every incident; these plots track cumulative burned area versus UTC time, offering a visual check on growth dynamics and timestamp integrity.

Reproducibility is ensured by a fourth directory, NIROPS_Code, which supplies the code processing pipeline. To repeat the workflow for other years or regions, a Python script (NIROPS.ipynb) automates retrieval of the raw NIROPS folders from the National Interagency Fire Center FTP site, performs projection, quality-control checks and produces the two sets of PNG supplements.

Technical Validation

To ensure the reliability and consistency of the dataset, we implemented a systematic, programmatic validation process using Python. We verified that all records shared a consistent coordinate reference system (CRS) and that temporal attributes followed the expected format to identify any incorrectly recorded timestamps. Perimeter areas were calculated and evaluated to confirm logical temporal patterns, such as consistent growth or stability over time (Figure 3). In some instances, for example on August 26^{th}-27^{th} 2021 for the Caldor Fire (in Figure 3), there was no recorded growth in fire perimeter between consecutive IR perimeters followed by a sudden expansion of subsequent IR perimeters over the next five days. These types of pauses in fire growth are common on large wildfires burning over extended periods of time due to unfavorable weather, diurnal shift, terrain features or suppression activities that temporarily stop fire progression until conditions change. This kind of non-linear growth is a common phenomenon observed during the active stages of large wildfire events[24]. In cases where formatting issues or errors were detected, these were flagged for further manual review. This automated quality control step helped maintain data integrity, reduced the risk of manual oversight, and provided a transparent visual framework for verifying the dataset's spatial and temporal properties.

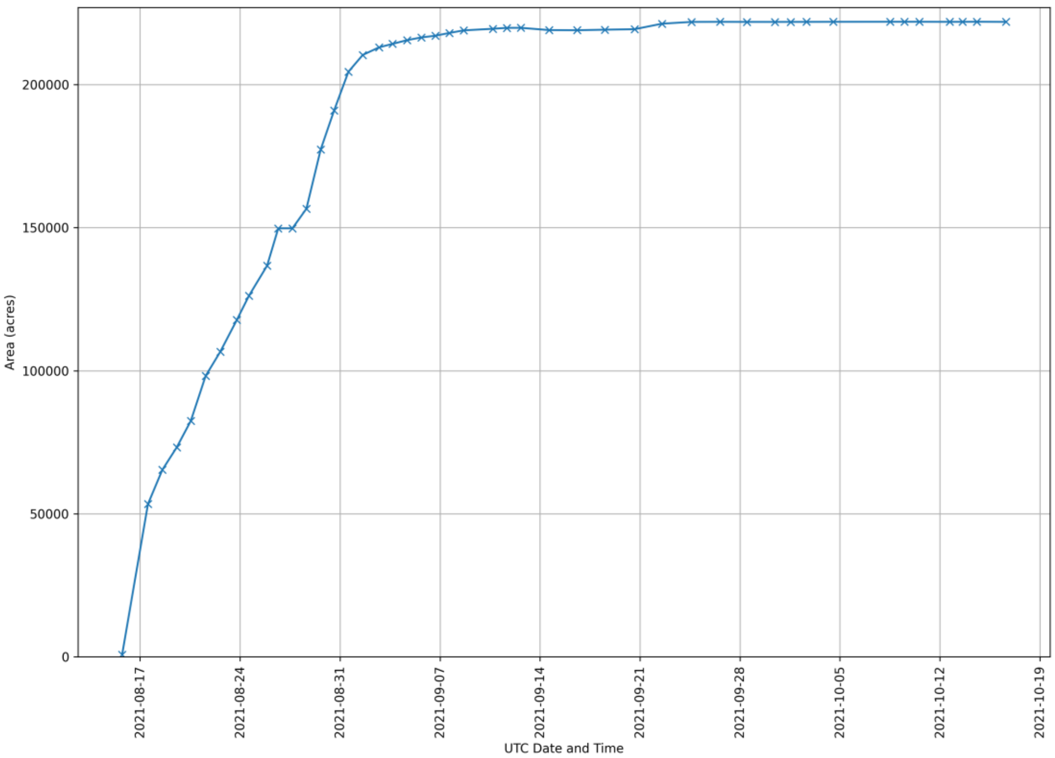

Figure 3. Caldor Fire area progression over time, August–October 2021 with 'x' represents the datapoint.

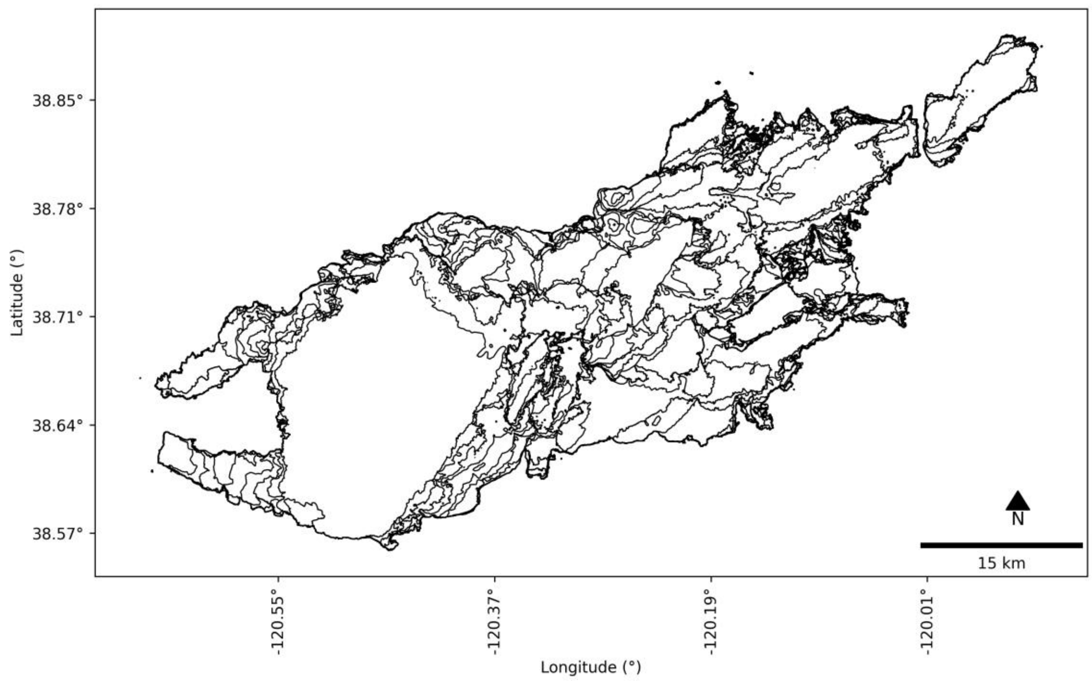

Figure 4. Example visual inspection of a fire perimeter (Caldor Fire). The plotted quick-look png includes a scale bar to aid in identifying outliers and validating the dataset's overall spatial consistency.

Each fire event was also visually inspected to ensure data integrity, complementing the programmatic validation process. Using Python, we generated detailed maps of fire perimeters for each event, incorporating scale bars for spatial context. These maps were manually reviewed to identify and address any outlying features or spatial outliers associated with other fire events, often resulting from mislabeling or incorrect interpretations by data contributors. Figure 4 highlights this validation process using the Caldor Fire dataset, demonstrating the combined available fire perimeters and their spatial distribution. Figure 5 presents the log-transformed fire area (acres) plotted against UTC date and time for all fire events, grouped by U.S. Forest Service region. Together, these steps provided a visual and analytical assessment of dataset quality.

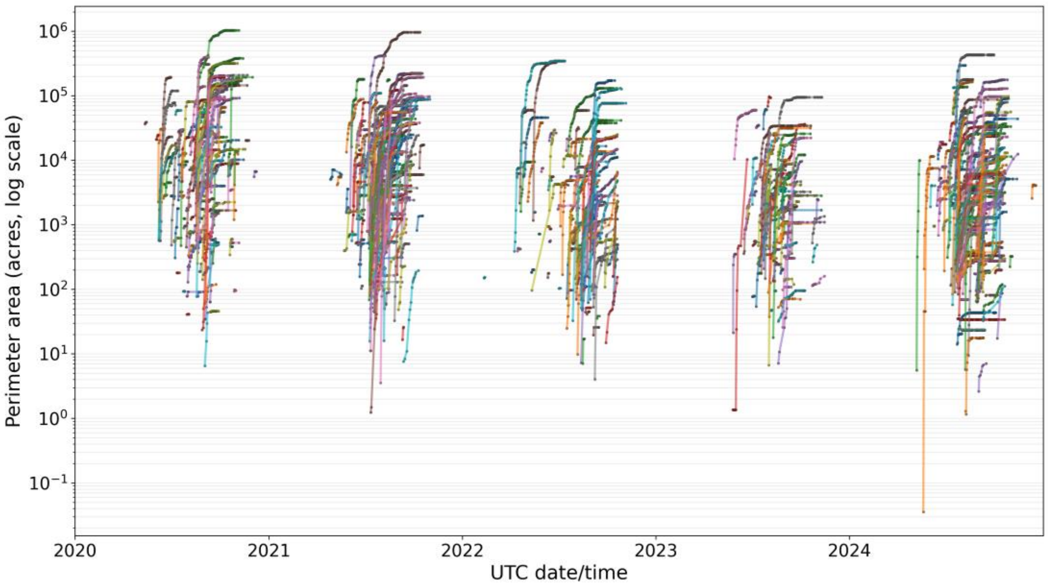

Figure 5. Log-transformed fire area (acres) plotted against UTC date and time across the dataset. This visualization highlights the temporal progression of fire perimeters, enabling the identification of potential mislabeling or anomalies in the data.

The dataset encompasses 737 unique fire incidents (Incident_C) and 12,705 fire-specific observation days, representing individual NIROPS infrared perimeter snapshots collected throughout each event. The number of NIROPS collections per incident is right-skewed, with a median of 11 collections and an interquartile range (IQR) of 6 to 22 collections. The maximum number of collections for a single incident was 90. These statistics reflect a minimum inclusion threshold of three NIROPS collection days per incident, which should be considered when interpreting the distribution.

The perimeter extents are shown from 2020 to 2024 (Figure 6). The NIROPS dataset reflects how infrared perimeter mapping is typically used as an ordered resource for larger or more complex incidents. At the time of the first recorded perimeter, the median fire size was 897 acres, with an IQR from 225 to 3,967 acres, and a maximum of 182,508 acres. These values indicate that NIROPS is rarely deployed during the earliest stages of small fires; rather, it is typically ordered once an incident has grown substantially or exhibits potential for rapid expansion. In contrast, the maximum fire size recorded per incident, often representing the final or near-final mapped extent, had a median of 4,558 acres (IQR: 1,062–21,284 acres) and a maximum of 1,032,280 acres. This distinction underscores NIROPS's primary role in capturing the growth phase and operational evolution of larger and more complex fire events.

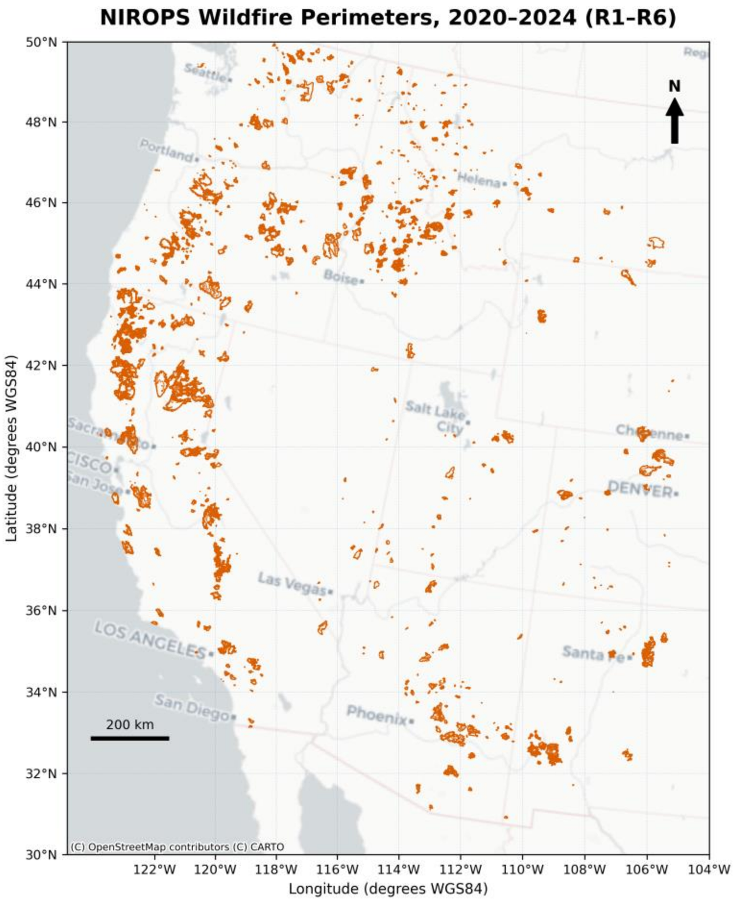

Figure 6. The final spatial extent of the dataset showing all fire perimeters available from incidents occurring between 2020 and 2024 that met the selection criteria.

We were unable to validate the interpreted perimeters against the original infrared imagery, as those source data are not publicly accessible. Consequently, the accuracy of the individual delineations created by IRINs could not be independently verified. Our quality assurance process was therefore limited to identifying and correcting technical or logical inconsistencies apparent within the perimeter data itself, such as abrupt reductions in fire extent, errors potentially introduced during the manual interpretation and digitization process, or outliers inconsistent with expected temporal progression. While this approach ensures internal consistency and removes evident digitization artifacts, it cannot evaluate the positional accuracy or interpretation quality of the original IRIN products. The resulting dataset thus represents a standardized and curated compilation that emphasizes logical and spatial-temporal coherence rather than revalidation of source imagery accuracy.

Usage Notes

The dataset is designed for research and operational analyses that require high-resolution, time-stamped wildfire perimeters. Typical applications include progression mapping, incident-level summaries, validation of coarser products, retrospective fire-behavior analyses, evaluation of treatment effects, and training/benchmarking of machine-learning models.

The NIROPS dataset carries several important caveats regarding scope and interpretation. Because NIROPS is an ordered resource, data collection typically begins once a wildfire has reached a moderate to large size or has become operationally complex; as a result, the earliest ignition growth and final containment perimeters are often absent. While perimeters are generally collected on a daily or sub-daily basis, temporal coverage can be irregular due to factors such as weather, airspace restrictions, or changing operational priorities. The fire perimeters themselves represent human interpretations of infrared imagery, meaning that while our quality control procedures ensured internal logical and temporal consistency, positional accuracy relative to the original infrared data could not be independently verified.

A single NIROPS perimeter represents the interpreted boundary of a wildfire at a specific point in time, derived from airborne infrared imagery collected during a NIROPS flight and informed by knowledge of the previous day's mapped extent. Each perimeter provides a snapshot of the fire's spatial footprint at the time of image acquisition. These boundaries do not always indicate where the fire was actively burning or spreading, nor where suppression efforts were successful or stalled. To analyze fire movement, rate of spread, or control effectiveness, users must incorporate multiple perimeters from different timestamps to capture temporal change. However, the intervals between NIROPS acquisitions are not uniform and should not be assumed to represent consistent time steps like those produced by orbital sensors such as MODIS or VIIRS. Instead, NIROPS data provides high-resolution, event-specific depictions of fire extent that are best interpreted in conjunction with their temporal sequence.

Code Availability

Data preprocessing and verification were conducted using the Python version 3.10 and code is publicly available for download at https://data.mendeley.com/drafts/95rj5d379g.

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Author contributions

SM: Formal Analysis, Data Curation, Investigation, Methodology, Software, Validation, Visualization, Writing – original draft
RW: Data Curation, Investigation, Methodology, Validation, Visualization, Writing – review & editing
MAW: Methodology, Software, Validation, Writing – review & editing
TJM: Data Curation, Methodology, Writing – review & editing
ES: Data Curation, Methodology, Writing – review & editing
YW: Funding acquisition, Project administration, Supervision, Writing – review & editing
CDO: Funding acquisition, Conceptualization, Direction, Project administration, Supervision, Writing – review & editing

Competing interests

The authors declare no competing interests.

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