



A reference Landsat burned-area dataset over Mediterranean Algeria (1984–2025) with an assessment of historical and new-generation products

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ABSTRACT

Algeria, the country with the largest mean annual and cumulative burned area (BA) on the southern rim of the Mediterranean Basin, experiences recurrent fires with substantial ecological and socioeconomic impacts. Yet, like many countries, it lacks a long-term, spatially explicit dataset of fire perimeters. Forest-agency records provide valuable fire information but are incomplete and contain discrepancies in BA location and extent, limiting fire-regime characterization. Available satellite-derived BA products offer systematic mapping at broad spatial and temporal scales and serve as the best available surrogate. Here, following internationally standardized protocols for BA dataset generation and validation, we present ALGEBa (ALGERia Burned Area), a 30-m BA reconstruction for fire-prone Mediterranean Algeria, derived from the Landsat archive for 1984–2025. Spatial validation against 10-m Sentinel-2 reference data for 2017 and 2021 yielded Dice coefficients > 90% and absolute relative biases < 3.5%, while median temporal reporting accuracy was 28 days against MODIS active-fire detections (2001–2011) and 24 days against VIIRS detections (2012–2025). Comparisons with forest-agency records and seven historical and new-generation BA products highlight ALGEBa as the most consistent and temporally continuous reconstruction of fire activity in Mediterranean Algeria to date, offering a robust basis for fire-regime analysis and Mediterranean-scale comparisons. Forest-agency records accounted for 70.6% of ALGEBa's cumulative BA, with strong interannual agreement. FireCCI51 overestimated BA twofold relative to ALGEBa, contrary to its widely reported global and regional underestimation bias. Used as a regional benchmark, ALGEBa revealed close cross-product consistency between VNP64A1 and MCD64A1 across the MODIS-to-new-generation transition, whereas Sentinel-3 products diverge from FireCCI51.

1. Introduction

In Mediterranean-type ecosystems, fire is a recurrent disturbance whose impacts are projected to intensify under near-term warming (Cunningham et al., 2025), and in Algeria, it has long been the leading driver of forest disturbance (Meddour-Sahar and Derridj, 2012). Records from the European Forest Fire Information System (EFFIS) (San-Miguel-Ayanz et al., 2012) indicate that, after Portugal and Spain,

Algeria had the largest mean annual and cumulative burned area (BA) among Mediterranean countries during the 2009–2025 period, and the largest mean fire size in North Africa. The severe 2021 and 2022 fire seasons revealed substantial societal impacts: large fires caused more than 150 fatalities and dozens of injuries, with USD 124.3 million in agricultural and property losses (World Bank et al., 2023b). With projected increases in heat-induced fire danger (Ruffault et al., 2020), Algeria stands out as a major regional fire hotspot. Although national

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forest fire policy was revised in late 2023, the country still lacks a consistent, spatially explicit, long-term fire record to support prevention, preparedness, and post-fire assessment.

Algeria has archival fire records extending back over 160 years (1860–present) (Madoui, 2002; Meddour-Sahar et al., 2008), offering a unique long-term baseline that may contribute to global fire-history reconstruction databases (Guo et al., 2025; Mouillot and Field, 2005); however, these consist of annual summaries with temporal gaps and lack systematic fire-perimeter cartography. Recent records compiled by the Directorate General of Forests (DGF) include annual fire counts and total BA, and its fraction by vegetation type from 1985 onward, with event-level attributes since 2012 (DGF, 2025). Yet, agency-based fire datasets are subject to uncertainty in reported BA (Pereira et al., 2011) and to gaps or unreliable records during conflict (Koutsias et al., 2013; Zubkova et al., 2021). They may also reflect political control over fire statistics (Belhadj-Khedher et al., 2018) and heterogeneous reporting protocols (Turco et al., 2016). An early comparison with satellite data revealed inconsistencies in reported fire size and geolocation for the northeastern part of the country (Kouachi et al., 2024). Fire perimeters produced by the Algerian Space Agency (ASAL) from medium-resolution ALSAT sensors remain inaccessible or are limited to recent periods (World Bank et al., 2023c). These limitations underscore the need for a standardized fire-perimeter dataset as keystone information for decision support and management plans.

Global satellite remote sensing provides systematic BA mapping capabilities and supports fire-regime characterization in data-scarce contexts (Chuvieco et al., 2019; García et al., 2022). Since 2000, MODIS imagery (NASA Terra/Aqua) has enabled standardized global BA products with multi-year coverage, notably MCD64A1 (Giglio et al., 2018) and FireCCI51 (Lizundia-Loiola et al., 2020). EFFIS also provides regional fire-perimeter information across Europe and the Middle East–North Africa, offering a useful surrogate for national statistics and, most importantly, a fully homogenized dataset across countries. More recently, next-generation global BA products have emerged to ensure continuity beyond the MODIS era, including VNP64A1 from S-NPP VIIRS (Giglio et al., 2025), C3SBA11 from Sentinel-3 OLCI (Lizundia-Loiola et al., 2021), and FireCCIS311 from Sentinel-3 Synergy data (Lizundia-Loiola et al., 2022). Despite these developments, coarse-resolution BA products can substantially underestimate BA by missing small and low-intensity fires (Chuvieco et al., 2022; Khairoun et al., 2024), highlighting the need for finer-resolution mapping where burned patches are subtle or difficult to delineate (Boschetti et al., 2015; Fornacca et al., 2025). This is particularly relevant in Mediterranean countries, where fire-size distributions are highly skewed toward smaller events (Belhadj-Khedher et al., 2018; Kouachi et al., 2024; Majdalani et al., 2022). Moreover, coarse-resolution products are restricted to the MODIS lifespan, while next-generation products have even shorter temporal coverage, collectively limiting the scope of long-term fire-regime analyses.

In response to strong end-user demand for finer spatial detail (Chuvieco et al., 2019; Mouillot et al., 2014), higher-resolution BA products have emerged mainly from Landsat and Sentinel-2 imagery, supported by advances in mapping algorithms (Roteta et al., 2021) implemented within the Google Earth Engine (GEE) cloud-computing platform (Gorelick et al., 2017). Examples include GABAM, currently the only available global annual 30-m BA product derived from Landsat time series (Long et al., 2019; Wei et al., 2021), and single-year Sentinel-2-based BA products for sub-Saharan Africa (Chuvieco et al., 2022; Roteta et al., 2019).

The growing availability of BA datasets, varying in sensor, processing chain, timespan and spatio-temporal resolution, has raised concerns among end-users about their reliability for regional studies, despite their widespread use in global applications such as climate and carbon-budget assessments (van der Werf et al., 2025) and biodiversity conservation (Cardil et al., 2026). Specifically, these concerns relate to whether such products accurately capture total BA (Katagis and Gitas, 2022) and

consistently detect fires above a minimum size threshold (Campagnolo et al., 2021; Nogueira et al., 2017; Zhu et al., 2017). An emerging issue is the temporal stability of global BA datasets across sensors, and their agreement with official fire statistics, which represent the only source of information before the remote-sensing era. To address this challenge for Algeria, as a representative case for the Mediterranean Basin, we use the Landsat archive which provides the longest continuous and relatively consistent medium-resolution record of Earth observation (Crawford et al., 2023). While Landsat-based BA products partly overcome coarse-resolution limitations, existing products derived from this archive still have important constraints: GABAM for instance lacks several years, reports only the year of burning, and presents recurrent commission errors (Clelland et al., 2024; Kouachi et al., 2024), while other datasets are restricted to specific years or regions (Eidenshink et al., 2007; Hawbaker et al., 2020). Consequently, existing global and regional BA products remain insufficient for analyzing the fire regime and its impacts in Algeria.

In response to the increasing national need for burned-area information, including a long-term overview, and the current challenges in merging multiple global BA data sources, we fill this gap by deriving accurate fire perimeters for fire-prone Algeria from the Landsat archive. This approach aligns with current efforts and national initiatives to reconstruct fire histories in data-scarce countries including most southern Mediterranean countries (Belhadj-Khedher et al., 2018; Majdalani et al., 2022), as well as similar initiatives in Portugal, Canada, and the U.S. (Eidenshink et al., 2007; Neves et al., 2023; Skakun et al., 2022). Our previous work (Kouachi et al., 2024) developed NEALGEB, a 30-m Landsat-based BA product for northeastern Algeria covering 1984–2023, using the Burned Area Mapping Tools (BAMTs) developed by Roteta et al. (2021). This dataset served as proof of concept, demonstrating the feasibility of reliable fire-history reconstruction in North African ecosystems; however, its narrow geographical scope limited the assessment of historical BA products and agency-based records while its timing predated the release of the new-generation VNP64A1 and FireCCIS311 products. Here we cover the full extent of Algeria's fire-prone region, hereafter referred to as “Mediterranean Algeria”, which excludes southern arid and desert areas with negligible fuel availability (FAO-DGF, 2022; DGF, 2025). This provides a comprehensive long-term BA record for the region where fire activity is concentrated (Curt et al., 2020). It also enables an extended comparison with global and regional BA products, including new-generation sensor-derived datasets that have rarely been assessed regionally in terms of cross-product consistency between sensor generations, thereby providing a reference case for the Mediterranean region. We specifically (1) generate an annual 30-m BA product from the Landsat 4–9 archive for Mediterranean Algeria, (2) assess its spatial and temporal reporting accuracy, (3) evaluate seven historical and new-generation BA products against independent reference data and agency-based records, and (4) assess the long-term reliability of agency-based records, and cross-product consistency between the MODIS-era products and their VIIRS- and OLCI/SLSTR-derived successors.

2. Materials and methods

2.1. Study area

The study area, located on the southern rim of the Mediterranean Basin, covers 210,651 km² (8.84% of Algeria). It extends from 33.91° to 37.09° N and from 2.22° W to 8.68° E, with elevations ranging from sea level to 2312 m. It encompasses the 43 northern Algerian provinces identified as fire-prone (FAO-DGF, 2022; DGF, 2025); its southern boundary follows administrative limits and excludes southern arid and desert environments where sparse forest vegetation limits fire spread. Climatic gradients drive drier conditions from east to west and from north to south. Mean annual precipitation is roughly 150 mm in the southernmost areas, 250–700 mm in the northwest, and 250 to

>1300 mm in the northeast (ANRH, 2005). Forests are dominated by broadleaved and coniferous species typical of Mediterranean ecosystems (Fig. 1).

2.2. Burned area datasets

2.2.1. GABAM

The GABAM algorithm was initially developed to produce the first global 30-m BA product for 2015, based on an automated Random Forest (RF) classification of dense Landsat time series (Long et al., 2019). Subsequent releases extended GABAM's temporal coverage to 1985–2024, although several years in the late 1980s and 1990s are missing (Wei et al., 2021).

2.2.2. FireCCI51, FireCCIS311 and C3SBA11

FireCCI version 5.1 (FireCCI51) is ESA's flagship global BA product, providing monthly 250-m BA maps for the 2001–2022 period, generated with a hybrid algorithm combining 250-m MODIS near-infrared surface reflectance and 1-km MODIS thermal anomalies (Lizundia-Loiola et al., 2020). FireCCI Sentinel-3 version 1.1 (FireCCIS311) builds on the FireCCI51 approach by combining Sentinel-3 Synergy surface reflectance from OLCI and SLSTR onboard Sentinel-3A/B with 375-m VIIRS active fires to produce 300-m global BA maps from 2019 onwards (Lizundia-Loiola et al., 2022). C3S BA version 1.1 (C3SBA11), the Copernicus Climate Change Service (C3S) global BA product, applies an OLCI-adapted version of the FireCCI51 algorithm to Sentinel-3 OLCI data, delivering monthly 300-m BA maps for 2017–2023 (Lizundia-Loiola et al., 2021).

2.2.3. MCD64A1 and VNP64A1

MCD64A1 (Collection 6.1) is NASA's standard global BA product, providing monthly 500-m BA maps from November 2000 to the present (Giglio et al., 2018), using a hybrid algorithm that combines 500-m MODIS surface reflectance with 1-km MODIS active fire observations. To extend continuity beyond the MODIS era, this algorithm was adapted to the characteristics of VIIRS on board Suomi-NPP, producing the

monthly 500-m VNP64A1 product (Collection 2) from March 2012 (Giglio et al., 2025).

2.2.4. EFFISBA

EFFIS provides fire-perimeter information for Europe and the Middle East–North Africa from November 2000 to the present. For Algeria, fire perimeters are available for 2004–2005 and from 2009 onward. Before 2018, fire perimeter delineation relied on the Rapid Damage Assessment (RDA) module, which mapped burned areas from daily 250-m MODIS imagery complemented by MODIS active-fire detections, CORINE land cover, and fire-news reports (San-Miguel-Ayanz et al., 2012). Since 2018, EFFIS fire contours have been generated using 20-m Sentinel-2 imagery, enabling higher-resolution perimeter delineation.

More details about satellite-derived BA products used in this study including their characteristics and global validation are summarized in Tables S1 and S2.

2.2.5. DGF fire dataset

Annual BA records were obtained from the national fire dataset compiled by the Algerian Directorate General of Forests (DGF, 2025). The DGF is the only authority in the country mandated to assess burned areas and report fire statistics to both national and international bodies including EFFIS. The dataset is available in two complementary versions. The first reports province-level fire statistics from 1985 onwards, including fire counts and total burned area by vegetation type. The second, available in digital format since 2012, includes fire-event attributes such as administrative unit, forest or locality name, geographic coordinates, ignition date and time, first-intervention and extinction time, fire size, BA fractions by vegetation type, and probable fire cause. Records prior to 2012 are mostly archived as individual fire incident reports.

Several caveats should nonetheless be acknowledged. The DGF does not report cropland fires, and fires outside the official May–November fire season may be under-reported or absent. Fire-size estimates may also contain uncertainties, as local forest districts often rely on visual field assessments that can be affected by limited accessibility, complex

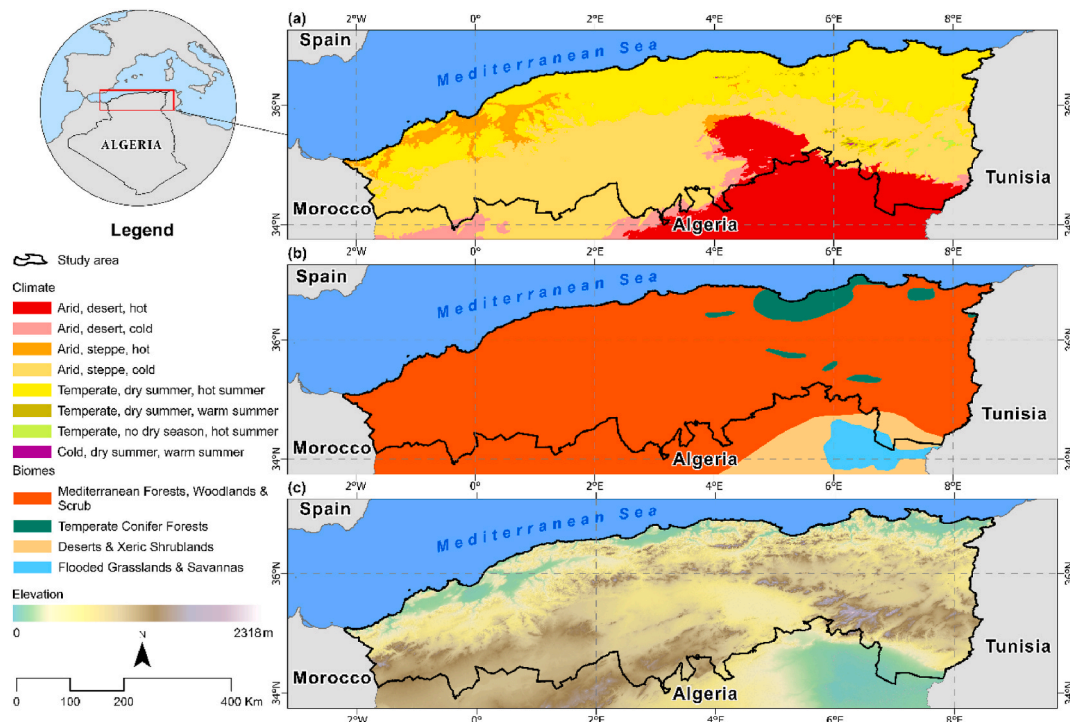


Fig. 1. Study area showing (a) Köppen-Geiger climate classification (Beck et al., 2023), (b) Biomes (Dinerstein et al., 2017), and (c) SRTM 1 arc-second elevation (NASA, 2013). The southern boundary follows the administrative limits of fire-prone provinces of Algeria (FAO-DGF, 2022; DGF, 2025).

land ownership, and non-standardized post-fire survey procedures. This is consistent with national diagnostic work indicating that fire reporting and geospatial information management in Algeria are still being standardized (World Bank et al., 2023c). As is common for agency-based fire inventories, this dataset belongs to an evolving administrative reporting system with limitations in standardization, spatial completeness, and temporal consistency (Gincheva et al., 2024). DGF records are therefore used here as the only agency-based benchmark available rather than an error-free reference.

2.3. Burned area mapping

For each year from 1984 to 2025, we applied the BA Cartography Tool v1.7 (Roteta et al., 2021) to pre- and post-fire image composites derived from the Landsat Collection 2 Level-2 Surface Reflectance Tier 1 product (Crawford et al., 2023). Clouds and cloud shadows were masked using the QA_PIXEL band and surface reflectance rescaled with the standard Collection 2 transformation; no snow or saturation mask was applied. Bands were harmonized by per-sensor selection (bands 1–5 and 7 for Landsat 4–7; bands 2–7 for Landsat 8 and 9), and Landsat 7 SLC-off pixels were masked as invalid without gap filling. DGF fire-start dates for 2012–2023 ($N = 23,506$) indicate a well-defined May–November fire season during which 99.6% of fires occur, with a marked peak in July–August (64.7% of fires). Only 0.4% of fires fall outside this season (DGF, 2025). This seasonal pattern, previously observed in northeastern Algeria (Kouachi et al., 2024), is typical of Mediterranean environments with long dry seasons, where fire activity is driven by summer drought and fire-weather conditions (Turco et al., 2016). Annual pre- and post-fire composites were built from all available Landsat 4–9 images acquired between 1 January and 30 April and between 1 May and 31 December, respectively. Over the 1984–2025 period, 29,403 Landsat 4–9 scenes entered the compositing workflow, with median annual availability of 567 scenes. This total comprised 9267 scenes acquired during the pre-fire period and 20,136 during the post-fire period. The post-fire window was extended to December to account for detection delays related to the 8–16-day Landsat revisit time and cloud contamination, and to ensure the capture of late-autumn fires.

The tool performs semi-automatic BA mapping using an RF classifier with 500 trees and a minimum node size of 10. In addition to pre- and post-fire VNIR and SWIR reflectance, the algorithm computes the NDVI, NBR, and NBR2 indices. Burned pixels were identified from the post-fire and pre-fire image-composites difference. The classifier was initially trained using representative burned and unburned polygons; additional polygons were added after each iteration following visual inspection of the burned-probability image to address identified omission and commission errors. Training was refined until complete visual inspection of the processing area revealed no remaining spatially coherent misclassification requiring further training samples. A standardized quality-control procedure was applied across the study area for each year of 1984–2025. Training polygons were defined through on-screen interpretation of the post-fire composite, together with the pre-fire composite and the difference image, all displayed as SWIR–NIR–red false-color composites. An average of 217 burned and 455 unburned training polygons were used annually, covering approximately 7114 and 16,730 ha per year, respectively. No fixed minimum polygon size was imposed: the smallest burned and unburned training polygons were 0.18 and 0.64 ha, respectively.

Interpretation of the burned/unburned training polygons was complemented by MODIS and VIIRS active-fire products (Giglio et al., 2016; Schroeder et al., 2014), FireCCI51, MCD64A1, and DGF records. These auxiliary datasets were occasionally consulted to confirm fire detection in cases of uncertain classification and were not used in BA delineation, although this role may imply a limited degree of non-independence. Before 2001, when MODIS-based products were unavailable, or whenever uncertainty persisted, the Image Viewer Tool (Roteta et al., 2021) was used to inspect available Landsat or Sentinel-2 acquisitions between

user-defined dates. This additional inspection helped to reduce commission and omission errors during the iterative refinement of the classification. Next, a two-phase supervised strategy was applied to each RF probability image to balance omission and commission errors (Bastarrika et al., 2011): seed pixels with a strong burned signal were first extracted using a threshold defined as the mean of the mean RF probabilities within each burned training polygon; then a region-growing procedure was applied from these seeds to neighboring pixels with burn probabilities $\geq 50\%$ using Rook's-case contiguity, and only burned patches containing at least one seed pixel were labeled as burned. A practical constraint of this workflow is the GEE user-memory limits, which can be exceeded over large processing extents, particularly in high-fire years requiring extensive training and region-growing. The study area was therefore partitioned into multi-province blocks while maintaining balanced training samples and avoiding overly complex geometries.

Detection dates are derived from the post-fire composite. This composite is built using an NBR-based quality mosaic that selects, for each pixel within the May–December period, the acquisition with the minimum NBR value, thereby capturing the strongest burn signal, and stores its acquisition date in a dedicated date band (Roteta et al., 2021). Burned patches are then vectorized from the burn-probability image and overlaid on this date layer. For each polygon, the dates of all intersecting pixels are extracted, and the modal date is assigned as the detection date for the corresponding burned patch. Therefore, these dates correspond to the most frequently observed post-fire acquisition date within each burned patch.

The 42 annual BA maps (1984–2025) were exported as $2^\circ \times 2^\circ$ tiles in vectorized format, with a 0.1° overlap between adjacent tiles, and merged into a single product, hereafter referred to as ALGEBa (ALGERia Burned Area). Two tiling artefacts were corrected in a GIS environment: (1) duplicate polygons, where the same fire was mapped in both of two adjacent tiles were dissolved; and (2) polygons split across tile boundaries were merged manually, with the burn date of the largest burned patch assigned to the final merged feature. Two further post-processing steps were applied: (1) visual quality control followed by manual refinement, and (2) filtering of isolated patches. Manual refinement was limited to removing rare narrow strip artefacts with a negligible effect on total BA, as previously described by Kouachi et al. (2024). In the latter step, patches of up to three pixels (0.27 ha) were removed unless at least one pixel lay within 30 m of another burned pixel, following Obando-Cabrera et al. (2025). Polygon areas were computed geodesically in WGS84 (EPSG:4326). Finally, as an exploratory assessment of temporal change in annual BA, we applied the standard non-parametric Mann–Kendall trend test (Mann, 1945), as no significant serial autocorrelation was detected in the annual series (lag-1 $r = 0.08$; Ljung–Box $p = 0.87$). We estimated the magnitude of change using the Theil–Sen slope estimator (Sen, 1968).

2.4. Product validation

We followed the standard validation protocol applied to NEALGEBa, the northeastern Algeria product (Kouachi et al., 2024), which allows spatial and temporal errors to be assessed from higher-resolution reference data (Boschetti et al., 2010; Chuvieco et al., 2022; Stroppiana et al., 2025).

2.4.1. Spatial accuracy

Spatial uncertainty was assessed by comparing ALGEBa perimeters at 30-m resolution with higher-resolution reference perimeters at pre-sampled validation sites over a defined validation period (Boschetti et al., 2009; Franquesa et al., 2022b; Stroppiana et al., 2022, 2025). Accordingly, we created reference fire perimeters at 10-m spatial resolution across 18 validation sites of 20×20 km (400 km²) within the Mediterranean forest biome, using 251 consecutive Sentinel-2 image pairs acquired between 1 May and 31 December in 2017 and 2021

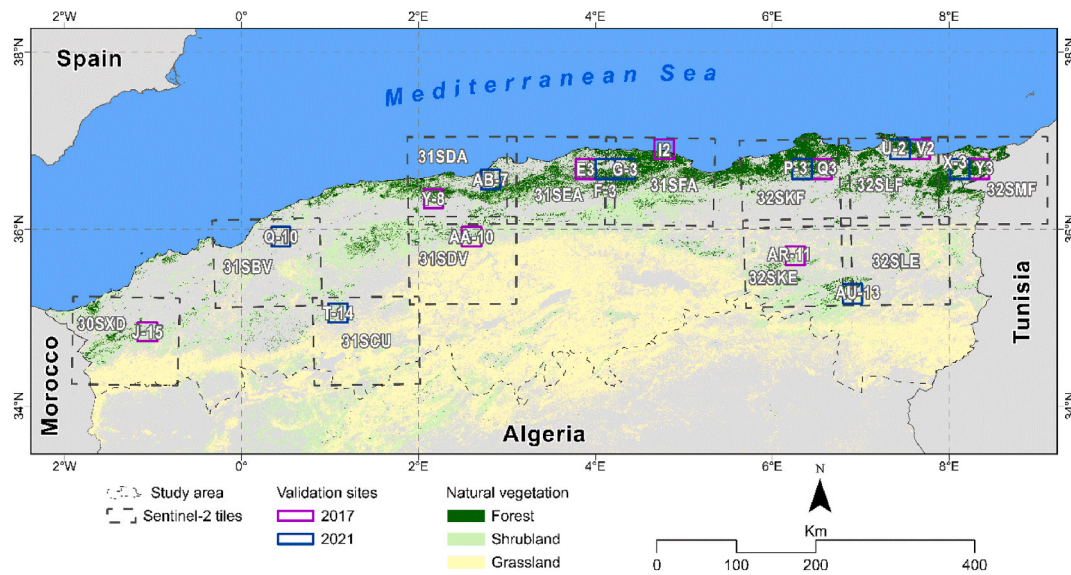


Fig. 2. Spatial distribution of validation sites ($20 \times 20 \text{ km}^2$) for reference years 2017 and 2021. Natural vegetation map (Zhang et al., 2024).

(Fig. 2). These two years were selected for their high fire activity within the Sentinel-2 era, ensuring a sufficient amount and diversity of burned areas. Earlier years could not be evaluated because Sentinel-2, which became available in mid-2015, is the only high-resolution data source suitable for our validation protocol. This corresponds to CEOS-WGCV Land Product Validation (LPV) stage-1 assessment, in which accuracy is estimated from a limited set of sites and periods using independent reference data (<https://lpvs.gsfc.nasa.gov/>, last accessed February 2026). A stage-3 assessment, requiring a probability sampling design that supports stratified inference across regions, vegetation types and fire-size classes, is left to future work.

BAMTs were used sequentially in GEE to (i) sample validation sites by stratified random sampling (VA Tool); (ii) select Sentinel-2 image dates within long temporal units ($\text{LUs} \geq 100$ days) (Franquesa et al. 2022a) with cloud cover below 30% and a maximum 30-day interval between image pairs (VA Dates Tool); (iii) generate 10-m Sentinel-2 reference data (S2RD) from multitemporal image comparisons using a semi-automatic RF classifier with manual refinement (RP Tool); and (iv) compute spatial accuracy metrics (Assessment Tool): commission error (Ce), omission error (Oe), Dice coefficient (DC), and relative bias (relB) (Roteta et al., 2021). Ce represents false burned detections, whereas Oe represents reference burned pixels missed by the BA product. Relative bias indicates the net over- or underestimation of total BA, while DC summarizes burned-class spatial agreement between the BA product and reference data. Ce, Oe, relB, and DC are calculated using the confusion matrix and are reported as percentages as follows, where TP (true positive) denotes burned area correctly mapped as burned, FP (false positive) denotes unburned area incorrectly mapped as burned, and FN (false negative) denotes burned area incorrectly mapped as unburned:

$$Ce = \frac{FP}{TP + FP} \times 100 \quad (1)$$

$$Oe = \frac{FN}{TP + FN} \times 100 \quad (2)$$

$$DC = \frac{2 \times TP}{2 \times TP + FP + FN} \times 100 \quad (3)$$

$$relB = \frac{FP - FN}{TP + FN} \times 100 \quad (4)$$

2.4.2. Temporal reporting accuracy

To assess ALGEBRA's ability to estimate the date of burning, detection

dates were compared with reference dates from the MCD14ML (2001–2011) and VNP14IMGTDL (2012–2025) active-fire products (Giglio et al., 2016; Schroeder et al., 2014) between 1 Ma y and 31 December. Active-fire footprints were constructed from nominal- and high-confidence hotspots using scan and track attributes to approximate the ground-sampling pixel size. Footprints were spatially joined to ALGEBa burned patches to identify intersecting detections. For each patch, consecutive day-of-year (DOY) values from overlapping footprints were grouped into temporal blocks, allowing gaps of up to 2 days to account for possible omissions caused by smoke, clouds, or weak thermal signal. The minimum DOY in the longest block was assigned as the inferred patch start date, consistent with the broader use of active-fire information to estimate fire timing (Boschetti et al., 2010). ALGEBa temporal reporting accuracy was quantified as the absolute difference in days and summarized separately for the MODIS and VIIRS reference periods. Because reference dates could only be assigned to ALGEBa patches intersecting active-fire footprints, potential selection bias was assessed by reporting the number and proportion of matched patches, their contribution to the total BA, and size distributions of matched and unmatched patches using the median and interquartile range (IQR).

2.5. Product intercomparison

We benchmarked ALGEBa against seven existing BA products of varying spatial resolutions (20–500 m) and the agency-based DGF dataset. The comparison focused on differences in annual BA estimates, consistency with DGF observations, and spatial agreement with S2RD reference data. To maximize the use of available data, inter-product comparisons were conducted over overlapping periods defined by product temporal coverage (Table S1).

Before comparison, all satellite-derived products were harmonized to a common vector representation at their native spatial resolutions in WGS84 (EPSG:4326) and clipped to the study-area boundary. Burned pixels were extracted from the burn-date layers of the MODIS, VIIRS, and Sentinel-3 products. GABAM is provided as raster annual maps and EFFISBA as vector fire perimeters. No confidence, uncertainty, or QA layers were applied, and all datasets, including DGF, were used as distributed.

Detections before 1 May were removed to align with the DGF reporting season, as only 0.4% of DGF records occurred outside May–November; GABAM was not temporally filtered due to the lack of

burn-date information (Long et al., 2019). Post-November detections were retained because satellite detection dates represent observation rather than actual burn dates and may therefore reflect delayed observation of late-season fires owing to revisit time, cloud contamination, or compositing (Neves et al., 2023).

Cropland fires were excluded using a previous-year natural-vegetation (forest, shrubland, and grassland) mask derived from GLC_FCS30D (Zhang et al., 2024) to better represent pre-fire conditions. Polygons with $\geq 75\%$ overlap with natural vegetation were retained as wildland fires. This threshold was empirically selected from a product-specific sensitivity analysis and removed 21.4–35.9% of total mapped BA across products. A similar approach improved satellite-benchmark agreement in Mediterranean Europe (Turco et al., 2019). Differences in annual BA estimates were examined in two steps. First, annual and cumulative BA were compared descriptively over all available years for each dataset, with DGF serving as an agency-based benchmark for assessing satellite-derived product consistency. Second, systematic differences among satellite-derived products were tested with the non-parametric Friedman test, with years treated as blocking units and products compared within each year (Friedman, 1937). ALGEBa, GABAM, EFFISBA, FireCCI51, MCD64A1, and VNP64A1 were compared over 2012–2022; these six products together with C3SBA11 were compared over 2017–2022; and all eight products, including FireCIS311, were compared over the 2019–2022 period. The Friedman test evaluates whether products tend to have similar ranks across years; larger χ^2 values indicate stronger overall differences among products. This design accounts for the paired structure of annual BA series, which are typically non-normal, right-skewed, and strongly influenced by extreme-fire years. When a significant overall product effect was detected, post-hoc exact Wilcoxon signed-rank tests were used to assess differences between product pairs, with p-values adjusted using the Holm procedure to control the family-wise error rate (Holm, 1979; Wilcoxon, 1945). Kendall's *W* was reported as an effect size of the Friedman comparisons.

Vegetation-specific comparisons with DGF used total annual BA for forest and shrubland classes, both combined and separately. Grassland was excluded because BA intersecting the grassland class of the natural-vegetation mask accounted for less than 0.2% of the cumulative BA mapped by ALGEBa over 2012–2022, an amount too small to support a meaningful comparison with the corresponding DGF class. Agreement with DGF was evaluated using Taylor-diagram statistics: the Pearson correlation (*r*), normalized centered root-mean-square error (cRMSE-norm), and normalized standard deviation (SDnorm) (Taylor, 2001). These statistics were first computed over 2012–2022, with C3SBA11 and FireCIS311 assessed over their full available periods (2017–2023 and 2019–2024, respectively). They were additionally computed over 2019–2022, the common period covered by all datasets. These metrics quantify temporal covariation, centered disagreement, and relative interannual variability, respectively. The same exact Wilcoxon procedure, with Holm-adjusted p-values, was used to test whether annual BA estimates from each product differed from the DGF benchmark.

For the spatial comparison, Ce, Oe, DC, and relB were estimated for all products in the common reference year 2021 by vector intersection with S2RD perimeters, using the same protocol as for ALGEBa. Statistical analyses were performed in R 4.4.1 (The R Core Team, 2024).

3. Results

3.1. Spatial and temporal patterns of burned area

The 42-year ALGEBa record (1984–2025) shows marked spatio-temporal variability in burned area, which is concentrated in the northeastern and north-central regions, particularly along the coast, whereas the northwest is less affected (Fig. 3a and b). This spatial pattern follows the east-to-west and north-to-south decreasing gradients of forest cover.

Over 1984–2025, ALGEBa detected a cumulative BA of 2.60×10^6 ha, with a mean annual BA of 61.90×10^3 ha yr⁻¹ (SD = 58.68×10^3 ha yr⁻¹). On average, forest fires accounted for 78% of the total wildland fires extent. The Mann–Kendall trend test detected no significant monotonic trend in annual BA ($\tau = 0.180$, $p = 0.095$), with a Theil–Sen slope of $+879$ ha yr⁻¹ (95% CI = -162 to $+2022$ ha yr⁻¹; $\sim 1.4\%$ of the long-term annual mean) (Fig. 3c). Annual BA varied widely, with 16 of the 42 years exceeding the long-term mean. The largest BA years were 1994, 2000, 2007, 2012, 2017, 2020, and 2021, together accounting for 1.12×10^6 ha, or 43%, of the total BA. By contrast, 1984, 1985, 1989, 2018, and 2024 recorded the lowest burned areas, together representing less than 1% of the total BA (21.50×10^3 ha).

3.2. Spatial and temporal reporting accuracy

Spatial accuracy varied among validation sites and between years (Fig. 4 and Fig. S1). Across all sites, ALGEBa achieved Ce = 8.32%, Oe = 11.49%, DC = 90.07%, and relB = -3.45% in 2017, and Ce = 7.74%, Oe = 6.53%, DC = 92.86%, and relB = $+1.32\%$ in 2021. The reported metrics are aggregated across sites. Site-level performance was more variable, with Dice coefficients ranging from 74.1% to 94.5% in 2017 (site mean 85.5%, median 88.1%) and from 76.8% to 95.2% in 2021 (86.6% and 88.2%) (Table S3a and Fig. S1a).

Active-fire detections from MODIS were matched to 43.4% of ALGEBa patches, while VIIRS matched 38.3%, representing 78.9% and 82% of its total BA, respectively. Matched patches were generally larger than unmatched patches, indicating a bias toward larger fires. Median temporal reporting accuracy was 28 days for MODIS and 24 days for VIIRS, with 54.6% vs. 59.5% of matched patches within 30 days of hotspot dates and 80.6% vs. 84.2% within 60 days (Fig. 5).

3.3. Product intercomparison

3.3.1. Annual burned area variability among products

Over the 1985–2025 period, DGF and ALGEBa showed broadly similar long-term temporal patterns, with major fire years synchronously identified in 1994, 2007, 2012, 2014, 2017, and 2021. However, DGF reported lower BA than ALGEBa, representing 70.6% of ALGEBa's cumulative estimate and a median annual ratio of 73.6% within natural vegetation. Over the periods covered by the other satellite-derived products, most products reproduced the main high-fire years, but annual BA estimates differed markedly, resulting in substantial differences in cumulative BA over 2012–2022 (Fig. 6a and b). FireCCI51 systematically produced the largest estimates, especially in extreme fire years, with a cumulative total 2.84 times higher than DGF, 2.08 times higher than EFFISBA, and 2.02 times higher than ALGEBa.

Comparisons between BA products were performed over three common periods defined by product availability, as described in Section 2.5 (Fig. 7). For the 2012–2022 period the Friedman test indicated significant differences among the six satellite-derived BA products ($\chi^2(5) = 25.70$, $p < 0.001$, $W = 0.47$), showing that certain products tended to rank consistently higher or lower in annual BA estimates across years (Fig. 7a). FireCCI51 produced the highest estimates of annual BA along with large interannual variability (median = 94.35×10^3 ha yr⁻¹; mean = 111.93×10^3 ha yr⁻¹; SD = 119.81×10^3 ha yr⁻¹), followed by GABAM, whereas EFFISBA yielded the lowest estimates. ALGEBa, MCD64A1, and VNP64A1 showed intermediate annual BA estimates with medians ranging from 32.44 to 36.17×10^3 ha yr⁻¹. However, pairwise Wilcoxon tests with Holm correction identified two significant differences between ALGEBa and GABAM and between EFFISBA and FireCCI51 (adjusted $p = 0.044$ for both). Including Sentinel-3-based products did not change the general pattern (Fig. 7b): the overall product effect remained significant over 2017–2022 when C3SBA11 was included ($\chi^2(6) = 17.50$, $p < 0.01$, $W = 0.49$) but was not statistically significant ($p = 0.158$) over the shorter 2019–2022 period when

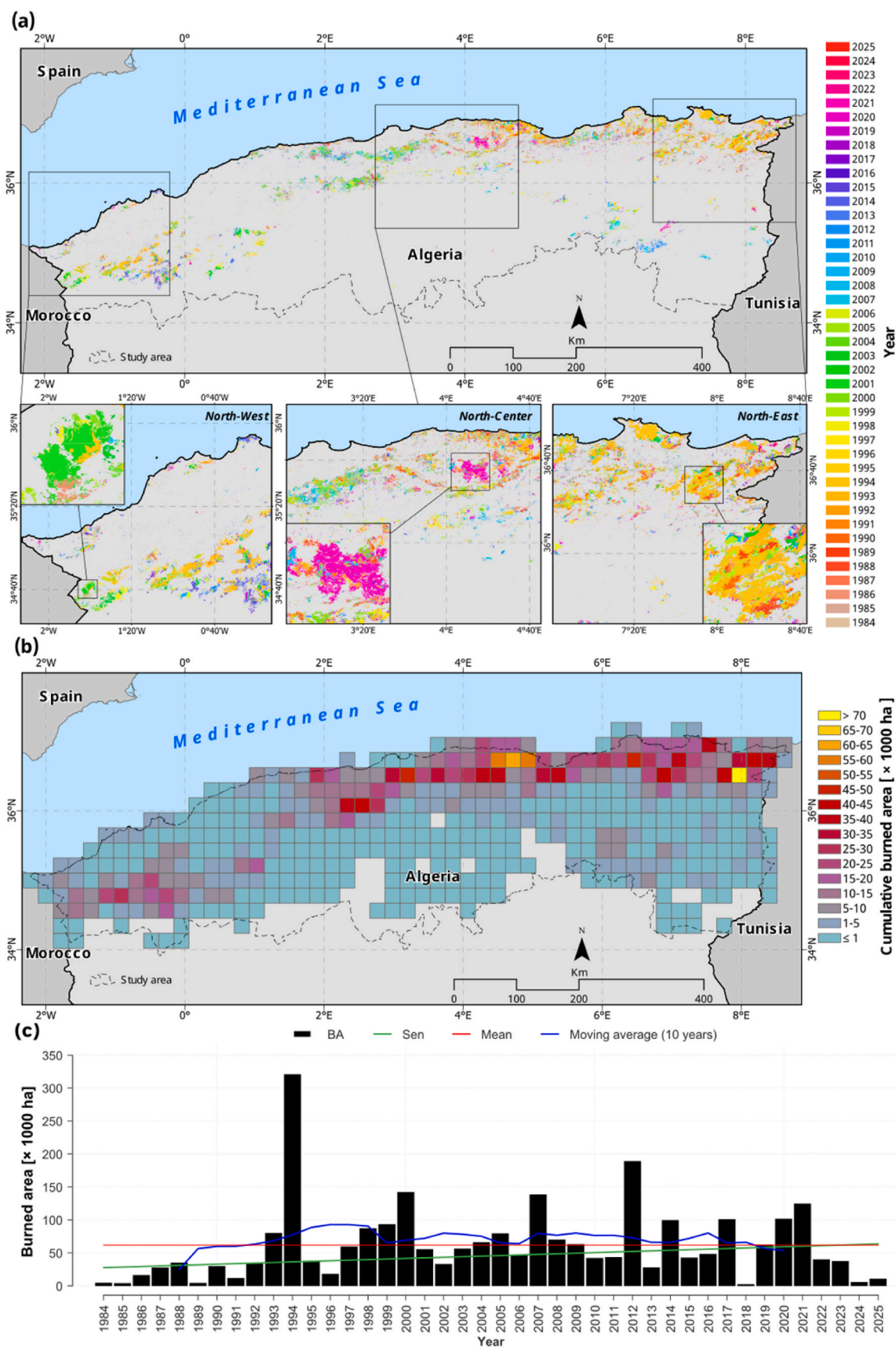


Fig. 3. Spatial and temporal patterns of burned area in Algeria's fire-prone Mediterranean region during 1984–2025 based on ALGEB. (a) Spatial distribution of historical fires, (b) Cumulative burned area during 1984–2025 aggregated over 20×20 km grid cells, and (c) Temporal trend of annual burned areas. (green line: Theil-Sen slope; red line: mean; blue line: 10-year moving average).

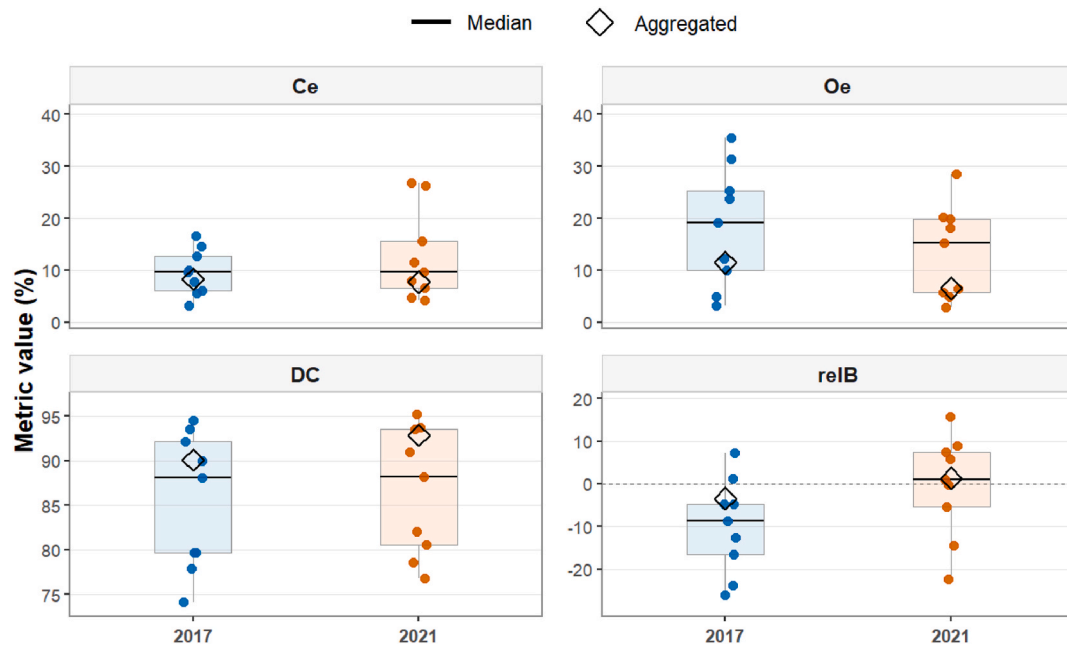


Fig. 4. Spatial accuracy metrics of ALGEBa assessed against S2RD at each validation site (circles) and across all sites combined (diamond) for 2017 and 2021. Ce: commission error; Oe: omission error; DC: Dice coefficient; relB: relative bias, all expressed as percentages.

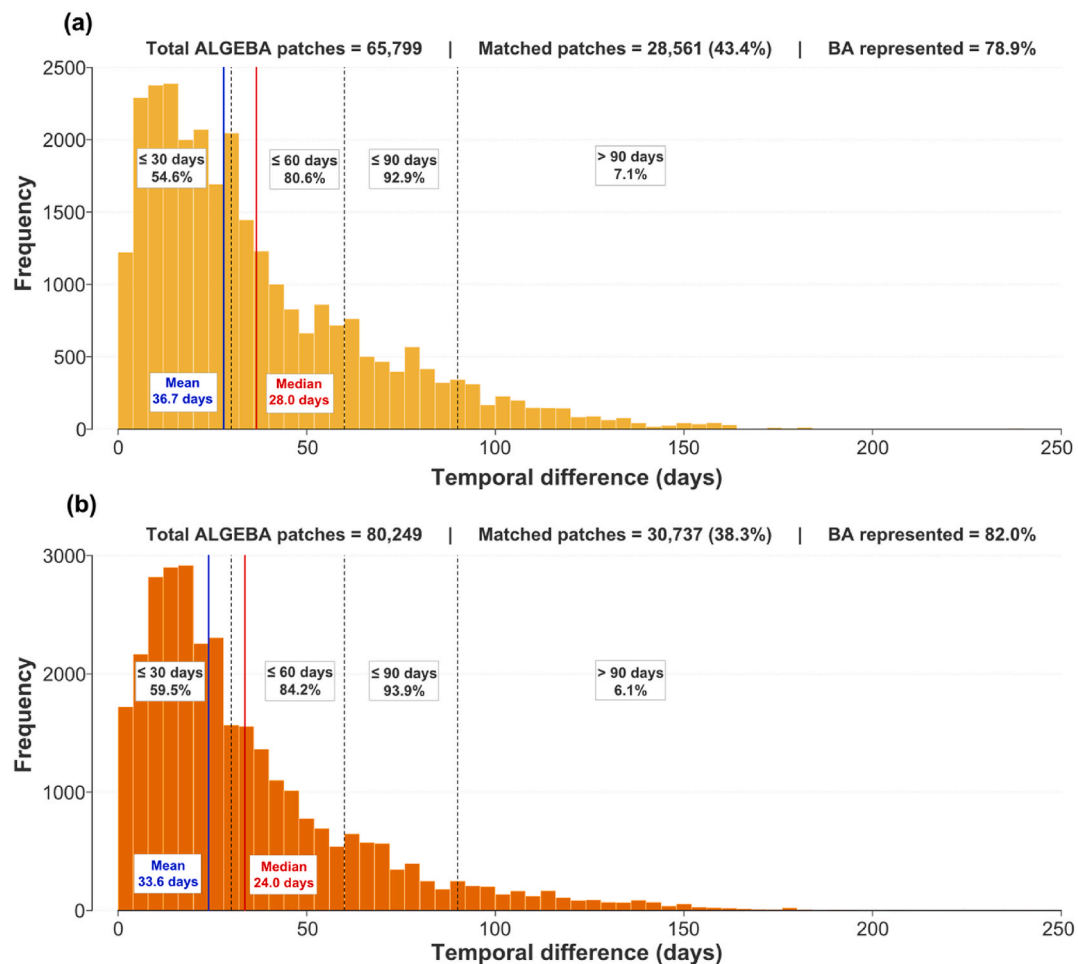


Fig. 5. Temporal reporting accuracy of ALGEBa relative to hotspot acquisition dates during (a) the MODIS reference period (2001–2011) and (b) the VIIRS reference period (2012–2025). Histograms show absolute temporal differences; vertical lines indicate the 30-, 60-, and 90-day thresholds, mean, and median.

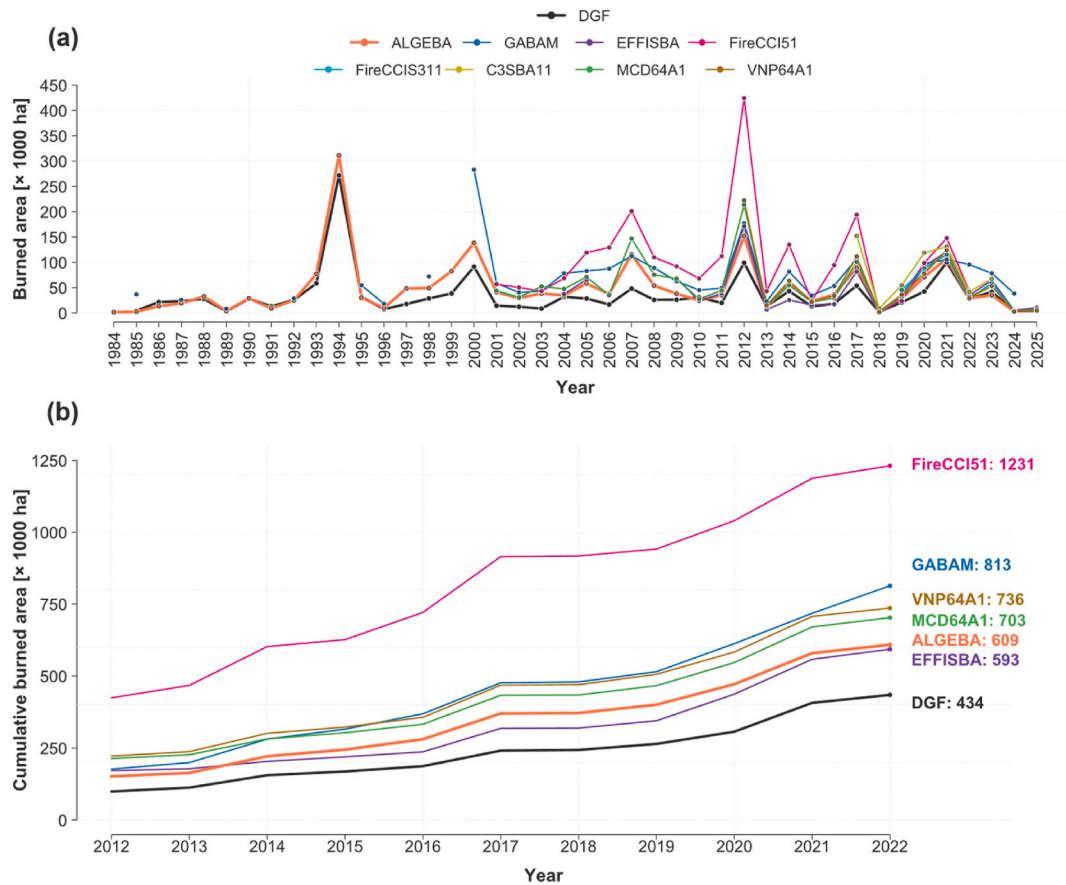


Fig. 6. (a) Annual BA estimates from DGF and all satellite-derived products (1984–2025), and (b) Cumulative burned area over the main common period (2012–2022). C3SBA11 and FireCCIS311 are not shown because of their shorter temporal coverage.

FireCCIS311 was also included ($\chi^2(7) = 10.58$, $W = 0.38$; Fig. 7c). Similar to its predecessor FireCCI51, C3SBA11 remained among the highest-estimating products, whereas FireCCIS311 showed intermediate values. No pairwise comparison reached significance in these two periods, although with six and four annual observations the smallest attainable Holm-adjusted p-values are 0.66 and 1.00, so pairwise inference is not supported at these sample sizes.

3.3.2. Annual BA agreement with DGF

Among the six products assessed over 2012–2022, ALGEBA showed the strongest agreement with DGF for annual BA in forest and shrubland combined, with the lowest cRMSEnorm (0.65) and highest correlation ($r = 0.95$). DGF and ALGEBA therefore track interannual variability closely, despite a systematic underestimation of total BA by DGF. This agreement in pattern does not, however, establish the absolute accuracy of either dataset. EFFISBA ranked second, while GABAM and MCD64A1 showed intermediate performance. FireCCI51 performed more poorly, with the largest error (cRMSEnorm = 2.78), weakest correlation ($r = 0.84$), and strongest overestimation of interannual variability (SDnorm = 3.57). Over the common 2019–2022 period, the new-generation ESA FireCCIS311 showed stronger agreement with DGF than C3SBA11 (cRMSEnorm = 0.58 and 0.77, respectively) and outperformed the standard FireCCI51 (0.69), whereas C3SBA11 did not. FireCCI51's poor performance over 2012–2022 is therefore driven largely by extreme fire years. When restricted to 2019–2022 its correlation with DGF is the highest among all products ($r = 0.96$), while its overestimation of interannual variability persists (SDnorm = 1.59). The new-generation NASA VNP64A1 showed performance almost identical to its standard NASA counterpart MCD64A1, both over 2012–2022 (cRMSEnorm = 1.22 and 1.15) and over 2019–2022 (0.42 and 0.43).

Over 2012–2022, performance for most global BA products was better for burned forest ($0.78 \leq r \leq 0.95$) than for shrubland ($0.40 \leq r \leq 0.82$), with ALGEBA remaining the best-performing product overall (Fig. 8a–c). The same pattern holds over the common 2019–2022 period, where shrubland correlations were consistently lower for every product. Exact paired Wilcoxon tests for combined annual BA indicated that all satellite-derived products estimated higher BA than DGF, with mean increase ranging from 64.35% (EFFISBA) to 223.20% (FireCCI51). After Holm correction, this difference was statistically significant for all satellite-derived products (adjusted $p = 0.008$ – 0.049 ; Fig. 8d).

3.3.3. Spatial agreement with S2RD

Spatial agreement between BA product maps and the S2RD reference data for 2021 is shown in Fig. 9, with the underlying confusion matrix elements reported for each product and validation site in Table S3a–e. Accuracy metrics varied across products, with commission errors reaching 25.53% for FireCCI51, omissions up to 11.18% for GABAM, and DC ranging from 83.34% for FireCCI51 to 92.86% for ALGEBA. GABAM and ALGEBA had the lowest Ce values (4.01% and 7.74%, respectively), while ALGEBA showed smaller Oe than GABAM (6.53% vs. 11.18%). These two products achieved the highest DC values (92.86% and 92.26%, respectively), reflecting the benefit of their finer resolution compared with coarser BA products at 250–500 m. EFFISBA, despite its 20-m resolution, showed an Oe comparable to ALGEBA (6.52%), but a higher Ce (12.44%), resulting in a slightly lower DC (90.42%). NASA's MCD64A1 and VNP64A1 displayed very similar performance across all metrics, suggesting continuity between the MODIS and VIIRS product lines. Although coarser than FireCCI51, the new-generation FireCCIS311 and C3SBA11, both at 300-m, outperformed FireCCI51. Local overestimation was especially evident for FireCCI51

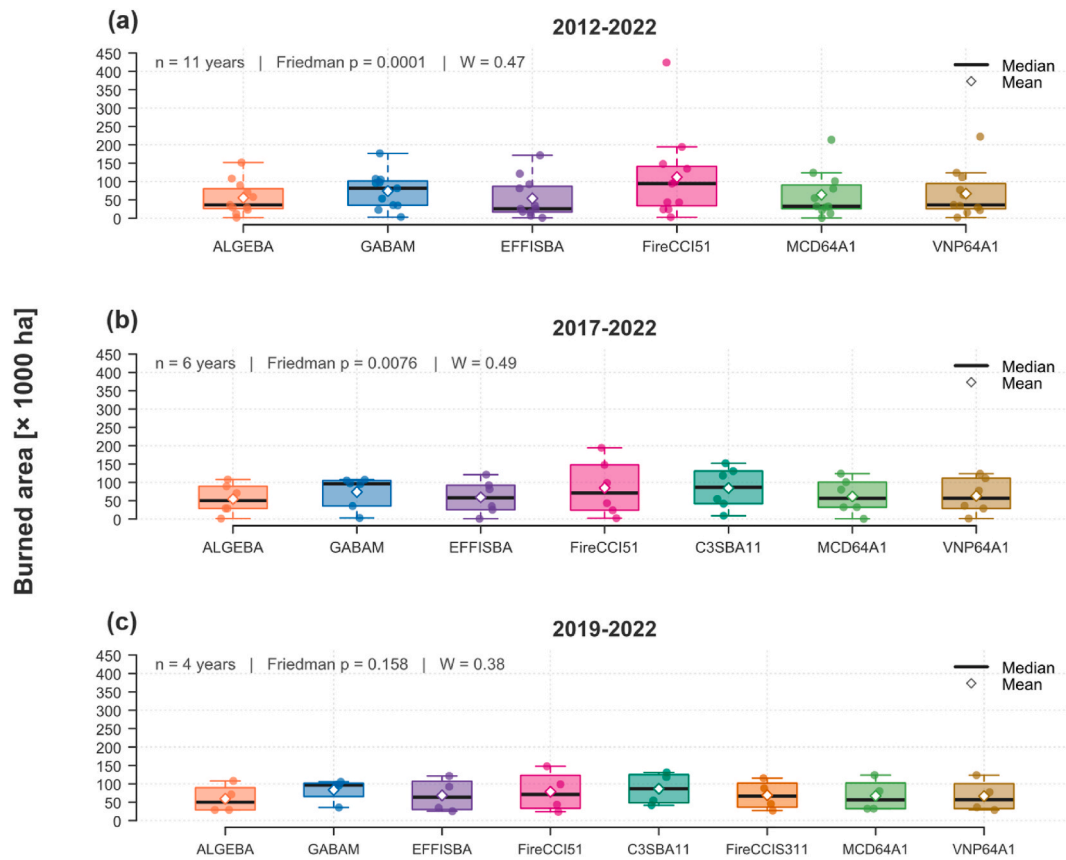


Fig. 7. Annual burned area average and variability across satellite-derived BA products over their common periods: (a) Comparison over 2012–2022, (b) Comparison including C3SBA11 over 2017–2022, and (c) Comparison including FireCCIS311 over 2019–2022.

and C3SBA11 at several sites, while complete detection failures occurred for some products. For instance, EFFISBA and VNP64A1 missed small burned patches of 4.49–27.98 ha at T-14, FireCCIS311 missed a 122.83-ha patch at Q-10, and MCD64A1 failed to detect fires at both sites. Overall, ALGEBA achieved the highest spatial accuracy, highlighting the limitations of coarser products for estimating actual BA extent, particularly where small or fragmented fires occur (see Fig. 10, Fig. S1 a–c, and Table S3 a–e).

4. Discussion

4.1. Reliability of official fire statistics

We based our assessment on Algeria's historical official fire dataset compiled by DGF. Such datasets, although highly variable in terms of accuracy, fire-type consideration, and fire-size thresholds (Mouillot and Field, 2005), remain valuable resources linking the remote-sensing era with paleo-reconstructions spanning centuries to millennia (Genet et al., 2025). Fire statistics covering recent decades have been assembled mainly for Europe and North America (Gincheva et al., 2024), with growing interest in century-scale reconstructions (Guo et al., 2025; Mouillot and Field, 2005). However, only a few countries have compiled such long-term records (Mouillot and Field, 2005), including Greece back to 1894 (Koutsias et al., 2013) and Algeria back to 1860 (Madoui, 2002).

Assessing the accuracy of official reporting is essential for strengthening confidence in these data and for revisiting potential misperceptions of fire trends derived only from short-term remote sensing-era records (Doerr and Santín, 2016). In this study, we used DGF statistics as an official agency-based benchmark, as is commonly done in fire-product assessment (Fusco et al., 2019; Galizia et al., 2021). Our

results indicate that DGF data are reasonably consistent with ALGEBA in capturing interannual variability, although they systematically report lower BA, representing 70.6% of ALGEBA's cumulative estimate within natural vegetation. This underestimation is understandable given the methodological challenges of field- and manual-based fire reporting in the absence of standardized remote-sensing processing chains (Kolden and Weisberg, 2007).

Changes in the agreement between ALGEBA and DGF further suggest variation in reporting consistency. Breakpoint analysis of the annual log ratio indicates a reversal in the mid-1990s: DGF reported slightly more BA than ALGEBA over 1985–1995 (ratio 1.09) and substantially less thereafter (0.63; $p < 0.001$), independently of interannual differences in BA. The break coincides with the Algerian Civil War in the 1990s, a period for which Meddour-Sahar et al. (2008) question the reliability of collected fire records and note that political events can alter how fires are counted. These results suggest that changing institutional capacity and periods of political instability should be carefully considered when using long-term official fire statistics.

4.2. Assessment of standard global remote sensing products

An important finding in this study was the substantial BA overestimation by FireCCI51. This is noteworthy because coarse-resolution global BA products such as FireCCI51 and MCD64A1 have been reported to underestimate BA, with omission errors exceeding commission errors (Boschetti et al., 2019; Franquesa et al., 2022a). The magnitude of this underestimation is substantial: version 1.0 of FireCCIS3 (FireCCIS310) detected around 27% more BA than FireCCI51 in 2019 (Torres-Vázquez et al., 2026). Regional studies similarly show that FireCCI51 and other coarse-resolution products detect substantially less BA than Sentinel-2-based products, largely due to the omission of small

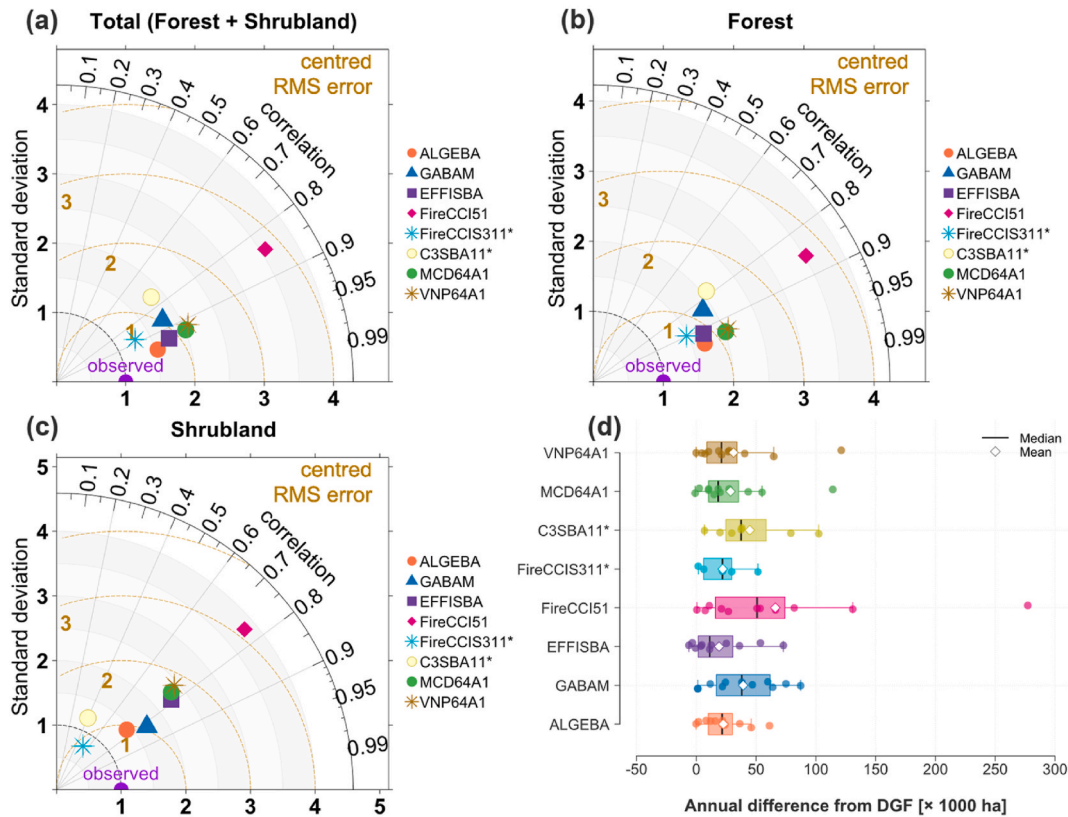


Fig. 8. Performance of ALGEBA and existing BA products relative to DGF in terms of annual BA estimates. (a–c) Taylor diagrams for total (forest and shrubland), forest, and shrubland burned area, respectively. (d) Paired annual BA differences relative to DGF for each product. Historical products were assessed over 2012–2022; new-generation FireCCIS311 and C3SBA11 products (asterisk) were assessed over all their available years, namely 2019–2024 and 2017–2023, respectively.

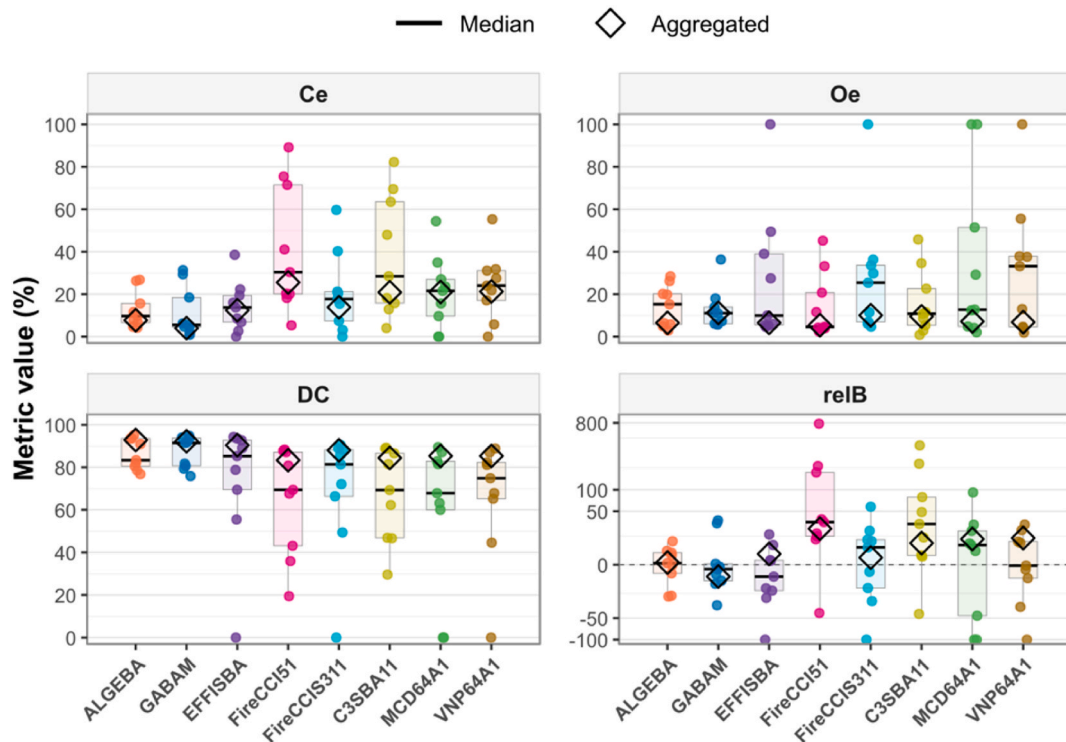


Fig. 9. Spatial accuracy metrics of the assessed BA products against S2RD at each validation site (circles) and across all sites combined (diamond) for 2021. Ce: commission error; Oe: omission error; DC: Dice coefficient; relB: relative bias, all expressed as percentages.

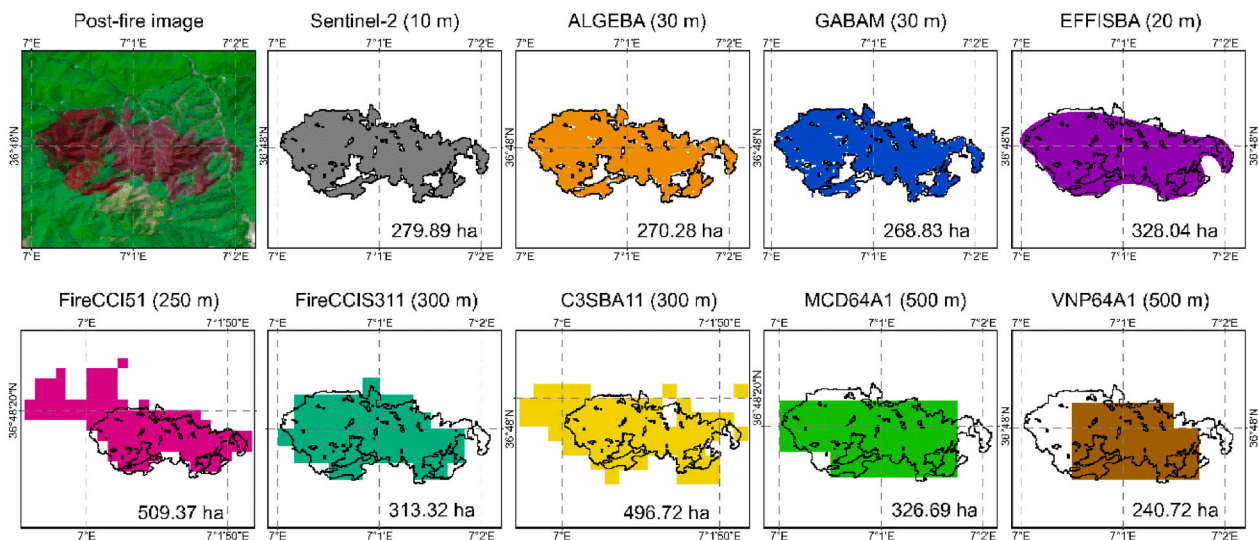


Fig. 10. Example of burned area contouring by ALGEBa and existing BA products, with the 10-m Sentinel-2 perimeter as reference.

or fragmented patches, particularly in tropical savannas and agricultural management fires (Chuvieco et al., 2022; Fernández-García et al., 2024; Khairoun et al., 2024). In Mediterranean Algeria, by contrast, FireCCI51 produced the largest annual and cumulative BA, exceeding ALGEBa twofold and DGF by a factor of 2.8 (2012–2022). The evidence of overestimation comes from the independent 2021 S2RD validation, which showed that this product, together with its related C3SBA11, had a strong overestimation bias compared with other datasets. Both products rely on NIR-based contextual growing intended to complete burned patches and reduce omission errors (Lizundia-Loiola et al., 2020), which we hypothesize may lead to the misclassification of dry-fuel areas near actual burned patches. This interpretation is consistent with Katagis and Gitas (2022), who found that FireCCI51 tended to over-delineate small fire scars in Mediterranean landscapes of Greece. Furthermore, error-source analyses have linked 70–80% of commission error to coarse pixel size and partial burning (Franquesa et al., 2022c), while Mediterranean intercomparisons showed an improved satellite–agency agreement after filtering cropland and urban detections (Turco et al., 2019). Thus, the overestimation observed in Mediterranean Algeria may reflect local over-delineation across mixed or partially burned pixels, rather than greater sensitivity to true BA (Fig. 10), though this remains to be tested directly.

4.3. Temporal stability across sensors with the new generation of global BA

ALGEBa delivers a reliable long-term burned-area record with the methodological characteristics expected of a reference dataset for product evaluation, within the limits of CEOS-WGCV LPV stage-1 assessment. Here, we provide a first regional assessment, for the Mediterranean Basin, of cross-product consistency between successive sensor generations, a critical step for ensuring reliability of temporal trend assessments (Padilla et al., 2014). We identified greater consistency between NASA's MCD64A1 and VNP64A1, which agreed, to a similar degree, with the DGF over both assessment windows, whereas ESA's Sentinel-3 products FireCCIS311 and C3SBA11 differed more from FireCCI51 in their agreement with DGF. It is worthwhile noting that these are comparisons of agreement with a common benchmark and do not constitute a formal temporal continuity test between sensor generations. However, the benefits of a fine-resolution Sentinel-2 imagery for detecting small fires are now widely recognized as critical (Khairoun et al., 2024; Ramo et al., 2021), and cross-sensor bias-correction efforts should continue to ensure temporal continuity (Fernández-García and Kull, 2023). This continuity issue is becoming critical across all

Essential Climate Variables (ECVs) (Benedict et al., 2021; Román et al., 2024) and should be further investigated for burned-area products and fire-emission protocols (Parrington et al., 2025). Harmonization efforts have begun, with MRBA60 combining FireCCI51 and FireCCIS311 through machine-learning bias correction, raising global BA relative to FireCCI51 (Torres-Vázquez et al., 2026). The opposite direction of bias we found over Mediterranean Algeria suggests that globally calibrated corrections require regional evaluation.

Similarly, providing a burned-area dataset spanning more than four decades helps fill the data gap in historical fire-trend assessment and the characterization of extreme fire events (Callister et al., 2016), while also enabling comparison with official statistics available before the remote-sensing era. This record could be extended to cover years before 1984 by analyzing Landsat MSS data, as has been done for Canada (Skakun et al., 2024) and Spain (Díaz-Delgado et al., 2004), although this would rely on 60-m resolution data with poorer temporal and spectral resolution. We encourage further long-term, consistently processed fire-history reconstructions to support the validation of global burned-area products and the assessment of cross-sensor continuity. Such datasets would also support analyses of fire legacy effects on carbon emissions (Yue et al., 2016) and ecosystem recovery (Vallet and Mouillot, 2026), which may take several decades for Mediterranean forest species (Rezgui et al., 2024) and are therefore difficult to capture with the current MODIS time series alone.

4.4. Strengths and practical value of ALGEBa

ALGEBa was generated over 1984–2025 within an iterative supervised workflow applied year by year, with consistent quality control across the full four-decade record. Although labor-intensive, this framework provides a cost-effective approach for fire-history reconstruction from the Landsat archive. This procedure has been applied across diverse ecosystems for such reconstruction (Fernández-García et al., 2024; Khairoun et al., 2026; Obando-Cabrera et al., 2025), including the Mediterranean Basin (Majdalani et al., 2022; Vallet and Mouillot, 2026), and could support the development of consistent datasets across neighboring countries. The trade-off is greater analyst involvement and operator dependence, making clear quality-control procedures and methodological transparency essential for reproducibility, consistent with Franquesa et al. (2022b), who showed that analyst expertise can significantly influence BA reference-data quality. In ALGEBa, processing the entire study area by a single analyst helped limit local interpretation biases; where present, such biases are expected to be systematic across the territory. This approach also reduces the risk

of inter-agency inconsistencies, as reported for fire-perimeter datasets in the U.S. (Short, 2014; Williams et al., 2025).

Within the evaluated sites and years, ALGEBA achieved Ce of 8.32% and 7.74%, Oe of 11.49% and 6.53% in 2017 and 2021, respectively, placing it at the high-accuracy end of previously published high-resolution BA products: GABAM reached Ce = 13.17% and Oe = 30.13% (Long et al., 2019); the USGS CONUS BA product reported Ce = 41% and Oe = 19% (Hawbaker et al., 2020); the recent Paramo Fire Atlas obtained a similarly low Ce (7.7%) but a much higher Oe (47.2%) (Obando-Cabrera et al., 2025), while the 20-m resolution FireCCISFD20 over sub-Saharan Africa reached Ce = 15.0% and Oe = 8.5% (Chuvieco et al., 2022). This level of accuracy indicates the potential of ALGEBA to contribute to global BA assessment exercises (Padilla et al., 2015), including long-term datasets (Otón et al., 2021).

Moreover, ALGEBA represents the longest spatially explicit and temporally continuous 30-m burned-area series for Mediterranean Algeria (1984–2025). It improves fire contour delineation and small-fire detection relative to historical and new-generation BA products (Fig. 10 and Fig. S1). This long-term dataset provides a basis for fire-regime characterization, fire-risk assessment, and comparison with other Mediterranean regions, while serving as a nationally relevant benchmark for evaluating future BA products and regional fire-activity assessments in North Africa. ALGEBA's value extends beyond retrospective fire analysis. In Algeria, technical reports emphasize the need to rebalance fire governance toward prevention, planning, and information-based management. Spatially explicit burned-area information can support this shift by identifying recurrently burned and fire-prone zones, guiding preventive-resource allocation, and informing restoration, fuel management, and post-fire monitoring (World Bank et al., 2023a). This relevance is further reinforced by the 2026 launch of a national fire-monitoring service, for which ALGEBA can provide a long-term historical baseline. ALGEBA can also support fire-reporting standardization and interinstitutional geospatial information systems by providing consistent BA perimeters that complement DGF records, ASAL fire-contour products, and future dynamic fire-management platforms. Such support is particularly relevant given recent recommendations to place forest planning and fire-risk analysis at the center of intervention, especially after the extreme 2021–2022 fire seasons, which caused substantial human casualties and damage to agriculture and housing (World Bank et al., 2023b). At the regional scale, ALGEBA may support Mediterranean emergency-preparedness frameworks, including the EU Civil Protection Mechanism and its Emergency Response Coordination Center (ERCC). By providing historical fire information for a non-EU Mediterranean country, particularly on past extreme events, it can help contextualize preparedness needs and support cross-border coordination and emergency assistance.

Among fine-resolution datasets, GABAM showed burned-area delineation accuracy comparable to ALGEBA and demonstrated potential for detecting small fires in complex landscapes (Fornacca et al., 2025). However, visual inspection revealed recurrent false positives, mainly over croplands and unburned forest vegetation, as well as spurious detections likely associated with Landsat 5 TM Scan Angle Monitor (SAM) malfunction (Fig. S2), as previously documented in northern Algeria (Kouachi et al., 2024). Similar GABAM limitations have been reported elsewhere, including missing-data problems (Zubkova et al., 2024) and Landsat-related artefacts (Clelland et al., 2024). Together with temporal gaps and the lack of burn dates, these limitations constrain GABAM's suitability as a stand-alone dataset for long-term fire analyses in Algeria. By contrast, the semi-automatic workflow used for ALGEBA, based on iterative RF training and visual quality control, mitigated such errors and produced a more consistent burned-area reconstruction. Although these artefacts may have limited influence on aggregate BA estimates, they can substantially affect local analyses of fire behavior.

4.5. Limitations and recommended use of ALGEBA

As with any satellite-derived BA product, certain technical limitations should be acknowledged. First, BA mapping is challenging in Mediterranean environments, where fragmented and heterogeneous mosaics of vegetation and land uses can produce ambiguous post-fire spectral responses and complicate the discrimination of burned areas (Lasaponara et al., 2023). Such conditions increase the risk of fragmented fire-patch delineation and local omission errors, particularly where burned areas are small, discontinuous, or embedded in heterogeneous land-cover mosaics (Kouachi et al., 2024). Consequently, a single fire event in ALGEBA may be represented by one or several adjacent fragmented burned patches, which might be split by firebreaks, missing data due to strips of Landsat 7 ETM⁺ SLC-off failure, or, in some cases, non-contiguous spotting fires characteristic of Mediterranean landscapes. Low-intensity understory fires may also be difficult to detect where limited canopy disturbance produces weak spectral changes (Pausas and Keeley, 2017). Omission and commission errors may further occur in sparsely vegetated areas, mixed land uses, and shadowed or topographically complex terrain, limiting full patch detection and increasing underestimation relative to fires in continuous dense vegetation. End-users may address this by clustering fragmented burned patches into fire events using custom spatial and temporal thresholds (Laurent et al., 2018).

Second, ALGEBA detection dates should be interpreted with caution as they do not necessarily correspond to the actual burning date; rather, they are proxy dates inferred from post-fire observations. Temporal reporting accuracy reflects the Landsat revisit interval (8–16 days), cloud and cloud-shadow contamination, and image compositing. Active-fire matching preferentially captured larger BA patches; although fewer than half of ALGEBA patches were matched, they represented more than 80% of total BA. The temporal assessment is therefore more representative of the majority of mapped BA than of the full patch population, particularly the numerous small unmatched patches. This may limit applications requiring highly accurate burning dates but is unlikely to be critical for annual, seasonal, and broad intra-seasonal analyses (Neves et al., 2023). In this context, products such as GABAM and the EU-scale disturbance database of Viana-Soto and Senf (2025), which provide only the year of burning, remain widely used.

Third, the scope of the validation should be noted. ALGEBA is spatially assessed for 2017 and 2021, and its temporal reporting accuracy from 2001 onwards, these being the periods for which suitable reference data are available. Sentinel-2 imagery started in mid-2015, and MODIS active fires have been available since 2001. Accuracy for earlier decades was therefore not evaluated, consistent with stage-1 assessment of CEOS-WGCV LPV (Section 2.4.1). Although the same mapping and quality-control procedure was applied throughout the full record (1984–2025), detection performance in earlier years may differ, particularly given SLC-off strips affecting Landsat 7 ETM⁺ acquisitions from 2003 onwards and the sparser image availability in the 1980s. For these reasons, the accuracy validation results reported here apply to the assessed years across Mediterranean Algeria and should not be extrapolated to earlier decades nor to other regions. Site-level accuracy was weakest where little burned area was available for assessment, and aggregated metrics were dominated by sites with larger burned areas.

Fourth, fire event information from FireCCI51, MCD64A1, and DGF datasets was occasionally consulted during training-sample interpretation (Section 2.3), in cases where the burned/unburned status of a candidate sample could not be resolved from the Landsat composites alone. These datasets were not used to delineate BA boundaries, but they are among those against which ALGEBA is compared, implying a limited degree of non-independence.

Taken together, these limitations define the applications for which ALGEBA is best suited. The dataset supports annual and long-term BA analysis at regional scale, comparison with other Mediterranean regions, and benchmarking of standard coarse-resolution BA products.

Conversely, event-level applications, including exact fire dates, daily fire propagation, individual fire counts, and low-intensity understory fires, require additional processing or independent verification.

5. Conclusions

Algeria has long lacked a consistent, spatially explicit record of fire perimeters, limiting fire-regime characterization and comparison with other Mediterranean regions. This study addresses this gap by developing ALGEBA, a 30-m Landsat-derived BA product for Mediterranean Algeria covering 1984–2025. Over 42 years ALGEBA mapped 2.6×10^6 ha of BA, with DC > 90% and absolute bias < 3.5% at the 2017 and 2021 validation sites, and achieved higher spatial accuracy than the seven satellite-derived products in the common reference year 2021. DGF estimates were 29.4% lower than ALGEBA cumulatively within natural vegetation over 1985–2025. Beyond its scientific value, ALGEBA provides a practical resource for fire managers and a transferable framework for reconstructing long-term BA records in neighboring Mediterranean countries where fire cartography remains scarce. We used this long-term fire dataset to provide a regional case study of cross-product consistency among standard global BA products during the transition from the MODIS era to new-generation products derived from VIIRS and OLCI/SLSTR. The NASA transition from MCD64A1 to VNP64A1 preserved agreement with the DGF benchmark more closely than the ESA transition from FireCCI51 to its Sentinel-3 successors. Future work should integrate in situ information collected by forest districts, including detection, intervention, and extinction times; ignition causes; firefighting expenditures; and damage assessments. The use of Landsat MSS imagery in GEE could extend the ALGEBA record into the pre-1984 period, although archive availability indicates spatially and temporally uneven coverage. Given its coarser spatial resolution and lack of SWIR bands, this extension would require an adapted NDVI-based change-detection approach, with cross-sensor consistency assessed during years when MSS and ALGEBA overlap. Finally, regular updates of ALGEBA would maintain its long-term relevance, strengthening its scientific and fire-management value.

CRediT authorship contribution statement

Mostefa E. Kouachi: Writing – review & editing, Writing – original draft, Visualization, Validation, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **Hassane Moutahir:** Writing – review & editing, Writing – original draft, Supervision, Methodology, Investigation, Conceptualization. **Magi Franquesa:** Writing – review & editing, Writing – original draft. **Amin Khairoun:** Writing – review & editing, Writing – original draft. **M. Jaime Baeza:** Writing – review & editing, Writing – original draft, Supervision, Methodology, Investigation, Conceptualization. **Florent Mouillot:** Writing – review & editing, Writing – original draft, Supervision, Methodology, Investigation, Conceptualization.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at <https://doi.org/10.1016/j.srs.2026.100526>.

Data availability

ALGEBA is publicly available at <https://doi.org/10.5281/zenodo.21839135>.

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