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FIRE-ADAPT

Project Deliverable D4.1

Dataset on fire history reconstruction from coarse and fine resolution remote sensing in study sites

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WP	Work Package

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Executive Summary

This deliverable, which is an outcome of WP4, describes the historical fire event databases obtained from coarse resolution (250-500m) global burned area datasets or locally processed at finer resolution (10-30m). This first deliverable within WP4 'modelling and forecasting' aims at processing, assembling, and documenting the fire datasets available in each Study Hub of FIRE-ADAPT, for further model development or benchmarking.

We assembled the available local fire datasets (if any), and leveraged the latest remote sensing information and semi-automated spectral band analytical tools to provide the most complete datasets. As a first-level target, we provide fire event polygons in shapefile GIS format, with attribute tables referencing at least the burned area, year/month/day of ignition. As a second-level target, we aimed to provide additional information on fire duration, spread rate and direction, intensity (Fire Radiative power), and severity (based on the dNBR index).

Data have been processed, compiled, stored, referenced as metadata, and communicated to the FIRE-ADAPT consortium for further use in WP4 modelling objectives and other WPs.

1 Introduction

This document, which presents and describes the FIRE-ADAPT project Fire history reconstruction over study sites, contributes to WP4 'modelling and forecasting'. The dataset described in this document is intended to provide to the modelling partners of the consortium the available fire data across study sites. Fire data represent the keystone information for i) statistical modelling of fire occurrence as a response to weather, landscape structure and human activities, and ii) fire spread model benchmarking across contrasted topographies, climate and ecosystems.

Based on the modellers' requirements, we targeted a first-order request for burned area, fire size and fire number, and daily dating of ignition, followed by a second-order request about fire intensity, rate of spread, and severity. To reach these goals we leveraged current state-of-the-art remotely sensed fire information and processing tools able to generate the missing information.

We first assembled available global datasets as a piece of homogeneous information across study sites. This information was then completed, by higher resolution information, either locally available in regional datasets or processed for FIRE-ADAPT objectives.

The document is structured as follows:

- Global datasets:
    - review of available datasets
    - FRYv2.0: description
- Local datasets: Country-level fire information
    - France
    - Spain (Catalunya)
    - Brazil
- Tools and training for generating fire information
    - Fire event identification: BAMTS: a semi-automated tool for fire identification from Landsat/Sentinel on Google Earth Engine
    - Fire Spread and intensity: FIRMS: hourly interpolation of fire spread from MODIS/VIIRS hotspots
    - Fire Severity: dNBR: a Google Earth Engine tool for fire severity mapping

2 Global Fire Datasets

2.1 Review of existing datasets

Since the year 2000 and the delivery of pixel-level burned area at a global scale, increasing needs going further than burned area alone has been requested by land surface modellers. Since the pioneering work of Archibald et al. (2013) first attempting pixel aggregation into fire patches, a few datasets have been generated and provided to the scientific community (Table 1). FRYv1.0 (Laurent et al. 2018) initiated a global dataset of fire patch morphology based on FireCCI4.1 and MCD45A1 burned area information. Andela et al. (2019) delivered the FireAtlas, including additional information on the final shapefile, ignition point and rate of spread, followed by GlobFire from Artes et al. (2019), trying to solve over-fragmentation issues from the previous datasets. Mahood et al. (2020) then provided FIRED, a piece of country-level information with pixel aggregation time threshold varying according to biomes, thus providing a range of datasets with specific outputs and a diversity of sensors used for burned area detection (Table 2).

Table 1: Major global fire event database available

Dataset Name	**Sensor /resolution**	**Period cover**	**reference**
FRYv1.0 FRY v2.0	MCD64A1 500m FireCCI51 250m	2001-2021 2001-2020	Laurent et al. (2018) Mouillot et al. (2023)
Fire Atlas	MCD64A1 500m	2001-2022	Andela et al. (2019)
GlobFire	MCD64A1 500m	2001-2019	Artes et al. (2019)
FIRED	MCD64A1 500m	2001-2019	Mahood et al. (2019)

Table 2: Main specificities of global fire event database available

	FRYv1.0	Fire Atlas	GlobFire	FIRED	FRYv2.0
MCD641	X	X	X	X	X
FireCCI51	X	-	-	-	X
Cut-offs	3,6,9,14 days				6,12 days
Ignition	-	X	-	X	X
ROS	X	X	X	X	X
Date	X	X	X	X	X
Duration	X	X	-	X	X
Morphology	X	-	-	-	X
Shapefile	-	X	X	X	X

2.2 FRYv2.0

FRYv2.0 was recently developed, and provides fire patches both using FireCCI51 250m resolution burned area information and MCD64A1 at 500m resolution. FRY v2.0 offer the advantages of combining burned area information and miscellaneous additional information as fire severity from MCD14ML (Fire radiative power, Giglio et al. 2016), and severity from the MOSEV dataset (Alonso-Gonzalez et al. 2021). We retained this global database as the reference information for FIRE-ADAPT for homogeneity, although the consortium has been aware of the availability of other datasets.

FRYv2.0 is a global dataset (figure 1), delivered as yearly shapefiles, available from IRD, and deposited (Mouillot et al. 2023) at OSU OREME observatory website (https://oreme.org/observation/foret/incendies/). The Attribute table of FRYv2.0 offers the information listed in Table 3.

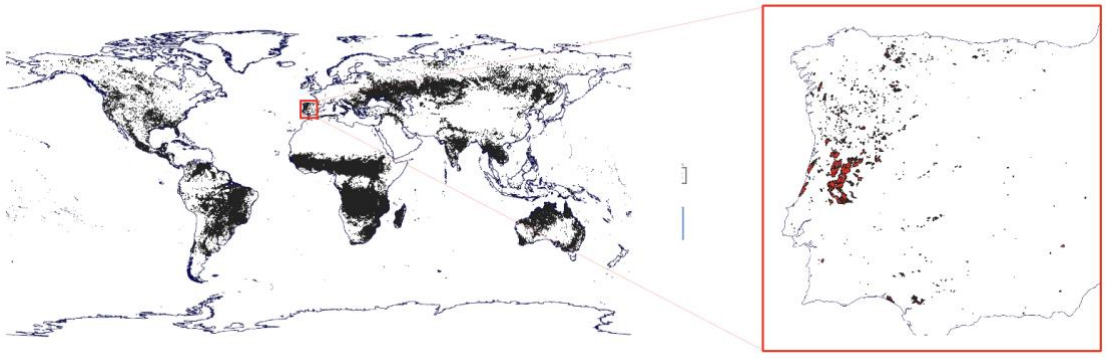


Figure 1: Global distribution of fire patches from the FRYv2.0 (year 2017) with screenshot on the Iberian Peninsula.

Table 3: Attribute table of information delivered for fire patch in FRYv2.0.

Column name	symbol	Class	Description	
L1		integer	most common land cover type	
L2		integer	second common land cover type	
L3		logical	third common land cover type	
LP1		numeric	% of the most common land cover type	
LP2		numeric	% of the second common land cover type	
LP3		numeric	% of the third common land cover type	
Sgm_X		numeric	Half-length of axis along the shorter axis of SDE (degree)	
Sgm_Y		numeric	Half-length of axis along longer axis of SDE (degree)	
patch_id		character	patch identifier	
LON		numeric	longitude of the patch centre in degree	
LAT		numeric	latitude of the patch centre in degree	
I_LON		numeric	longitude of the centre of the earliest BD clust	only availible for the results of Oom et al. 2016 algorithm
I_LAT		numeric	latitude of the centre of the earliest BD clust	only availible for the results of Oom et al. 2016 algorithm
Tht_Crr		numeric	Angle between the longer SDE axis and the North	(0-180 degrees)
Sig_X_m		numeric	Half-length of axis along the shorter axis of SDE (m)	
Sig_Y_m		numeric	Half-length of axis along longer axis of SDE (m)	
Eccntr		numeric	Eccentricity of the SDE (i.e.	the flatness of the ellipse)
sde_ar		numeric	Area of the SDE (m2)	
YR		integer	year of the earliest BD	
minBD		character	earliest BD of the patch	
maxBD		character	latest BD of the patch	
FSR		numeric	Fire spreading rate (Sig_Y_m / (maxBD - minBD + 1))	
L1		integer	ESA CCI land cover Code of the largest land cover type	
L2		integer	ESA CCI land cover Code of the second largest land cover type	

L3		integer	ESA CCI land cover Code of the third largest land cover type	
LP1		numeric	proportion of the largest land cover type	
LP2		numeric	proportion of the second largest land cover type	
LP3		numeric	proportion of the third largest land cover type	
n_cell	N	integer	number of cells	
n_cr.cl		integer	number of core (i.e. non-edge) cells	
n_edg_pe	P	integer	number of perimeter cell edges of the patch	
n_edg_in		integer	number of internal cell edges of the patch.	
area	A	numeric	area of each patch comprising a landscape mosaic (in km2)	
cr_ar	Acore	numeric	the interior area of the patch	greater than the specified depth-of-edge distance from the perimeter
peri		numeric	total length of the perimeter (m)	
peri_ar_r	P.A.R.	numeric	P/N	
shp_ind	S.I.	numeric	the shape complexity	sum of each patches perimeter divided by the square root of patch area
fd_ind	D2	numeric	fractal dimension index reflects shape complexity across a range of spatial scales	2 * ln(0.25*P)/ln(N)
CA_idx	C.A.	numeric	quantifies core area as a percentage of patch area	Acore/A
mdn_frp		numeric	median fire radiative power mapped to the SDE of the FP	using a 30-day delay
min_frp		numeric	minimum FRP	MCD14ML
max_frp		numeric	maximum FRP	MCD14ML
mindtc_frp		character	earliest FRP date	MCD14ML
maxdtc_frp		character	latest FRP date	MCD14ML
N_frp		integer	number of patches that hit a least one FRP data point	MCD14ML
mdn_BS		numeric	median Burn severity (dNBR)	MOSEV
avg_BS		numeric	mean burn severity (dNBR)	MOSEV
sd_BS		numeric	standard deviation of burn severity	MOSEV
N_BS		integer	number of BS points	MOSEV
max_BS		numeric	maximum BS	MOSEV
min_BS		numeric	minimum BS	MOSEV

mdn_frpf		numeric	median of FRP values mapped to the FP polygon	MCD14ML
N_frpf		integer	number of FRP hotspots mapped to the FP polygon	MCD14ML
mx_frpf		numeric	maximum of FRP values mapped to the FP polygon	MCD14ML
mn_frpf		numeric	minimum of FRP values mapped to the FP polygon	MCD14ML
mx_t_f		numeric	latest FRP hotspot mapped to the FP polygon, time since 0:00 31-12-2000	MCD14ML
mn_t_f		numeric	earliest FRP hotspot mapped to the FP polygon, time since 0:00 31-12-2000	MCD14ML
frp_a_0		numeric	First-day burned area estimated by vonoroi polygons based on FRP hotspots	MCD14ML
frp_a_1		numeric	Second-day burned area estimated by vonoroi polygons based on FRP hotspots	MCD14ML
i		i	i	
frp_a_14		numeric	14th-day burned area estimated by vonoroi polygons based on FRP hotspots	MCD14ML
mxdtc_ff		character	latest FRP hotspot date mapped to the FP polygon	MCD14ML
mndtc_ff		character	earliest FRP hotspot date mapped to the FP polygon	MCD14ML
ilon_f		longitude of the earliest FRP	median if multiple earliest hotspots exist	MCD14ML
ilat_f		latitude of the earliest FRP	median if multiple earliest hotspots exist	MCD14ML
geometry		POLYGON/POINT	Geometry of the fire patch	

3 Local dataset

3.1 Brazil

For the Brazil Study Hub (figure 2A), we uploaded the Brazilian Landsat-based fire polygons from MapBiomas Fogo (Collection 1.0) for the study period, 1985-2020 (Alencar et al. 2022, figure 2B). This dataset consists of maps where pixels are identified as either burned or not burned, along with the month in which the pixel was mapped as such. These maps were created from mosaics of Landsat images at 30 m spatial resolution with a 16-day interval. Specificities of the dataset are summarized in Table 3.

Figure 2: location of the Brazilian Study Hub (A) and representation of the fire data available (B).

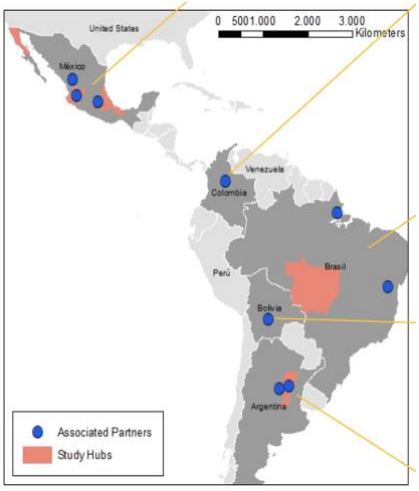
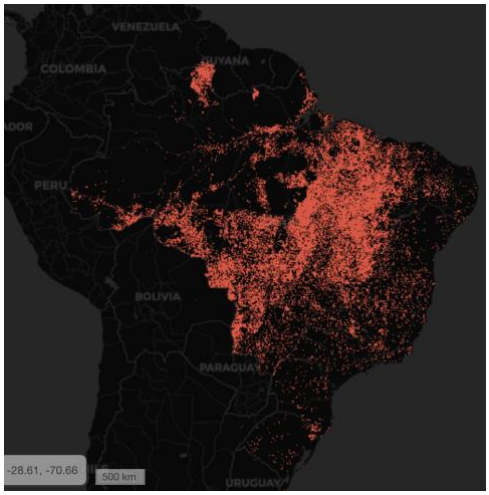
A) Study Area	B) Fire data
	

Table 4: description of the Brazilian local fire dataset.

information	description
Period covered	1985-2022
Sensor	Landsat
Temporal resolution	monthly
Spatial resolution	30m
Minimum fire size	20ha
Fire types (wildfires, cropland fires, prescribed)	All, not differentiated
Source to be cited	Alencar et al. (2022)
Link	https://plataforma.brasil.mapbiomas.org/fogo
Format	shapefile
FIRE-ADAPT contact	IRD-AMAP
Attribute table content	ID, burned area, ignition month

3.2 France

For France Study Hub (Figure 4A), no open-access spatialised fire data are yet available for the scientific community. Only fire events have been collected and assembled in the BDIFF (Base de données des Feux de Forêts, https://bdiff.agriculture.gouv.fr/) by IGN (Institut Geographique National) and Minister of agriculture and forest. Within Fire-ADAPT and the concomitant project EU H2020 Fireurisk, we processed large fire events (>20ha) referenced in BDIFF with the semi-automated fire identification tool BAMTS available on Google Earth Engine (Roteta et al. 2022). We could process 1578 fire events over the whole national territory (Vallet et al. 2023, figure 4B). In turn, each fire event is properly dated on a daily basis, with information on fire size, duration and fire type previously described in BDIFF. Specificities of the database are summarised in Table 5.

Figure 3: location of the France Study Hub in FIRE-ADAPT (A) and representation of the Fire data available (B).

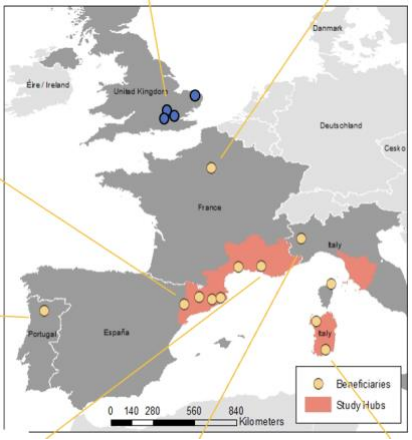
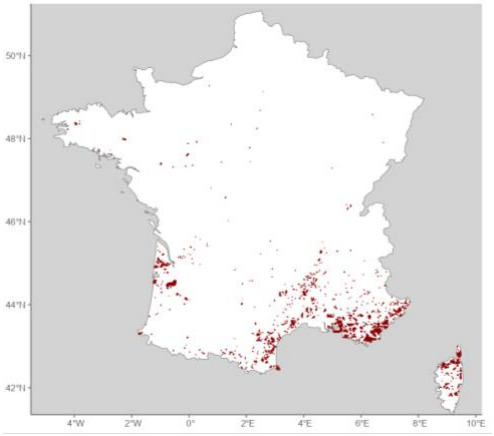
A) Study Area	B) Fire data
	

Table 5: description of the France local fire dataset.

information	description
Period covered	1985-2022
sensor	Landsat
Temporal resolution	daily
Spatial resolution	30m
Minimum fire Size	20ha
Fire types (wildfires, cropland fires, prescribed)	Wildfires
Source to be cited	Vallet et al. 2023
Link	https://oreme.org/observation/foret/incendies/
format	Shapefile/Geopackage
FIRE-ADAPT contact	IRD-CEFE
Attribute table content	ID, ignition date, burned area, duration

3.3 Spain

For Spain (Catalunya Region) Study Hub (figure 4), we uploaded fire data previously processed from Landsat archives (30m resolution) for Catalunya since early work from Diaz-Delgado et al. (2004) over the 1974 to 1998 and further updated until 2022. Each fire event is properly dated on a daily basis, with information on fire size. Specificities of the database are summarized in Table 5.

Figure 4: location of the Spain (Catalunya) Study Hub in FIRE-ADAPT (A) and representation of the Fire data available (B).

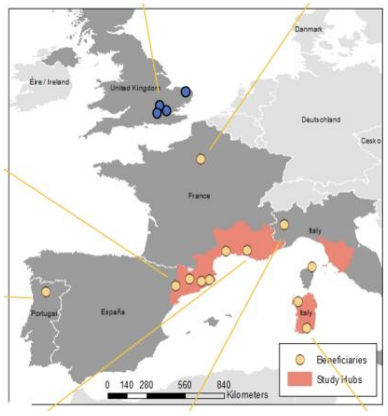
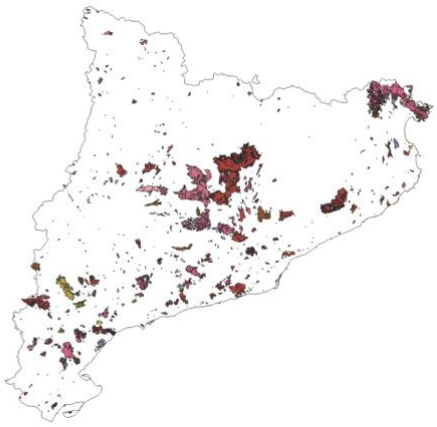
A) Study Area	B) Fire data
	

Table 6: description of the Spain (Catalunya) local fire dataset.

information	description
Period covered	1985-2022
Sensor	Landsat
Temporal resolution	daily
Spatial resolution	30m
Minimum fire size	10ha
Fire types (Wildfires, cropland, prescribed)	Wildfires
Source to be cited	
Link	
Format	Shapefile
FIRE-ADAPT contact	UDL
Attribute table content	ID, ignition date, burned area

4. Tools

Within FIRE-ADAPT, standardised protocols to develop fire data, together with additional keystone information on fire spread, intensity and severity, have been developed at IRD-CEFE. We intend to further develop the existing databases for missing data within Study Hubs, or develop further existing databases where prescribed fires have been hardly referenced. We present here the available free-access tools available and training activities that will be performed during the French Study Hub meeting (February 2025).

4.1 Burned Area Mapping

Burned area data can be semi-automatically and automatically generated following standard international protocols with the BAMTS freeware developed by Roteta et al. (2022) and recently updated by Bastarrika et al. (2024). For a given location and ignition date, BAMTS computes pre and post-fire composites of NDVI, NRB and NBR2 indices, from which the user defines training areas of burned and unburned pixels. From these training areas, BAMTS then automatically classifies all burned pixels following a random forest classifier and delivers the shapefile of the burned patch. Fine-tuning and visual checking allow for quality-checked burned area, to be used as a reference source of information for the automated classification procedure. This method has been used for the France Study Hub fire history reconstruction.

4.2 Fire Spread and Intensity

Fire spread rate and intensity can be derived from fire hotspots available since 2000 from the MODIS sensor (MCD14ML) at 500m resolution and VIIRS at 375m resolution since 2012. Hotspots provide the timing of the flaming (6hourly time step), and the energy released (Fire Radiative Power, MWatts). The spatial distribution of 6 hourly timing, converted into numeric decimal values, can then be interpolated with Krieging geostatistical tools (R cran, package ‘kriging’). The full processing chain developed by IRD-CEFE using R cran, was applied over the France Study Hub fire dataset (as described in Vallet et al. 2023, figure 5), and is available for the FIRE-ADAPT consortium.

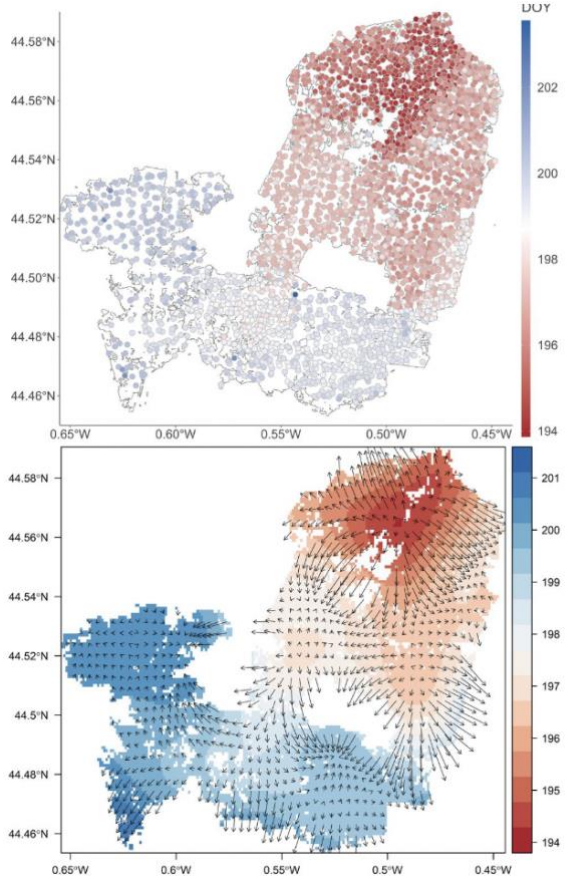


Figure 5: Fire hotspot distribution (day of the year, upper panel) and derived fire spread rate and direction over the 2022 Landes Forest (France) (extracted from Vallet et al. 2023).

4.3 Fire Severity

Fire severity described the fire impact on vegetation, and has been widely assessed from remote sensing by computing the pre- to post-fire change in normalized burned ratio index (NBR). We used the Google Earth Engine tools developed by Parks et al. 2018 to process dNBR information over fire polygons developed with BAMTS for the France Study Hub. Scripts and documents are available for the FIRE-ADAPT consortium and training activities will be proposed during the France Study Hub meeting (February 2025).

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