A methodological approach to identify thermal anomalies hotspots misclassified as fire pixels in Fire Radiative Power (FRP) products

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The 5th International Electronic Conference on Remote Sensing (ECRS)

Virtual event, 7-21/11/2023

Abstract

Thermal anomalies detected by Earth observation satellites have been widely used to identify active fires, even though with a high percentage of misclassified fire pixels. A total of about 75000 Fire Radiative Power (FRP) pixels have been spatially and temporally combined with EFFIS Burned Areas Database, distributed under the Copernicus Emergency Management Service, in order to identify thermal anomalies hotspots misclassified as fire pixels. The proposed approach uses a cluster analysis to partition FRP pixels dataset into discrete subsets, based on defined distance measures like the spatial distance of the pixel centroids and the temporal frequencies. Later, zonal statistics has been performed in order to evaluate fractional land cover within each identified hotspot. Results demonstrate that misclassified large surfaces, like industrial areas, can be identified from both spatial and temporal patterns, while other FRP false alarms are smaller in size.

Materials

- FRP-NRTD – Fire Radiative Power Near-Real Time Database
  - Collected datasets

Satellite	Sensor	Resolution	URL
Aqua (EOS PM-1)	MODIS	1000 m	https://firms.modaps.eosdis.nasa.gov
Terra (EOA AM-1)	MODIS	1000 m	https://firms.modaps.eosdis.nasa.gov
SNPP	VIIRS	375 m	https://firms.modaps.eosdis.nasa.gov
Sentinel-3	SLSTR	1000 m	https://www.eumetsat.int/S3-NRT-FRP

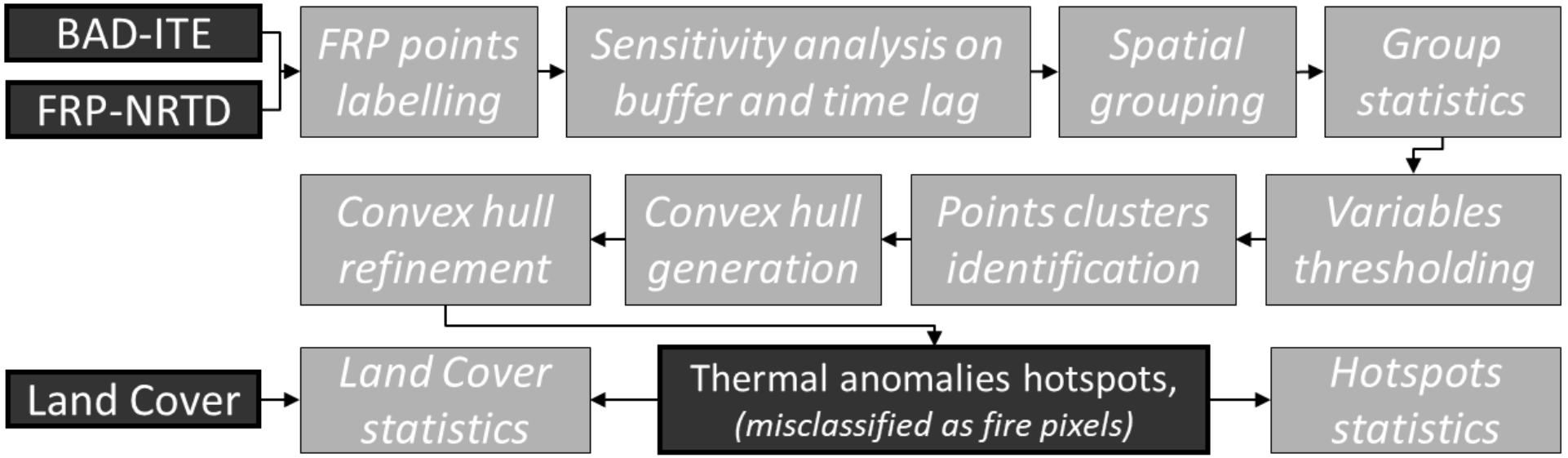
- BAD-ITE – Burned Area Database – Italian Terrestrial Ecosystems

https://groupware.sinanet.isprambiente.it/prodotti-operativi-di-sorveglianza-ambientale/library/disturbance-agents/wildfires/burnt-areas-italian-terrestrial-ecosystem

- CLC_bb 2018 – Corine Land Cover Backbone

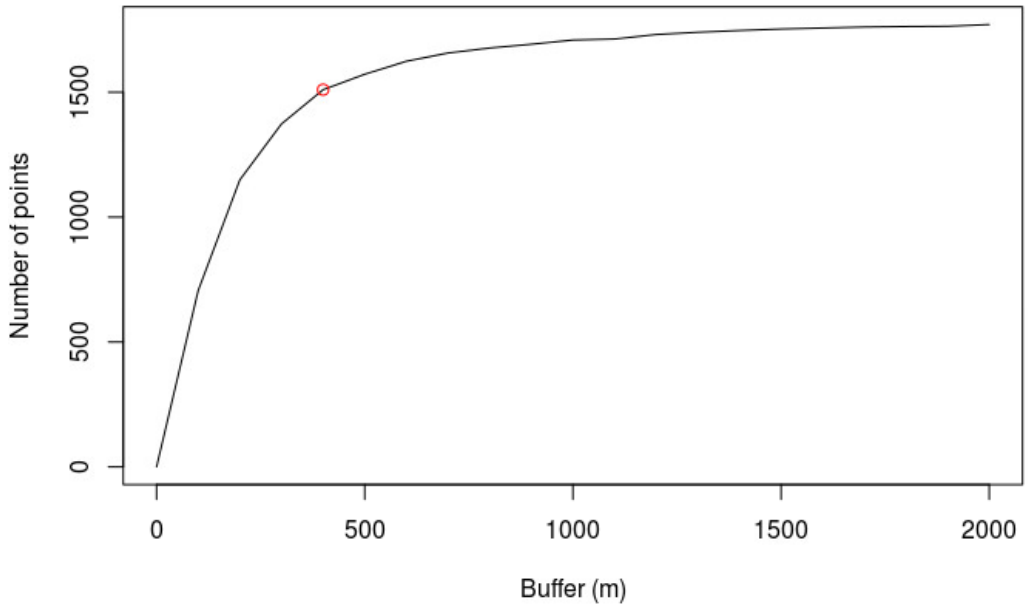
https://land.copernicus.eu/en/products/clc-backbone

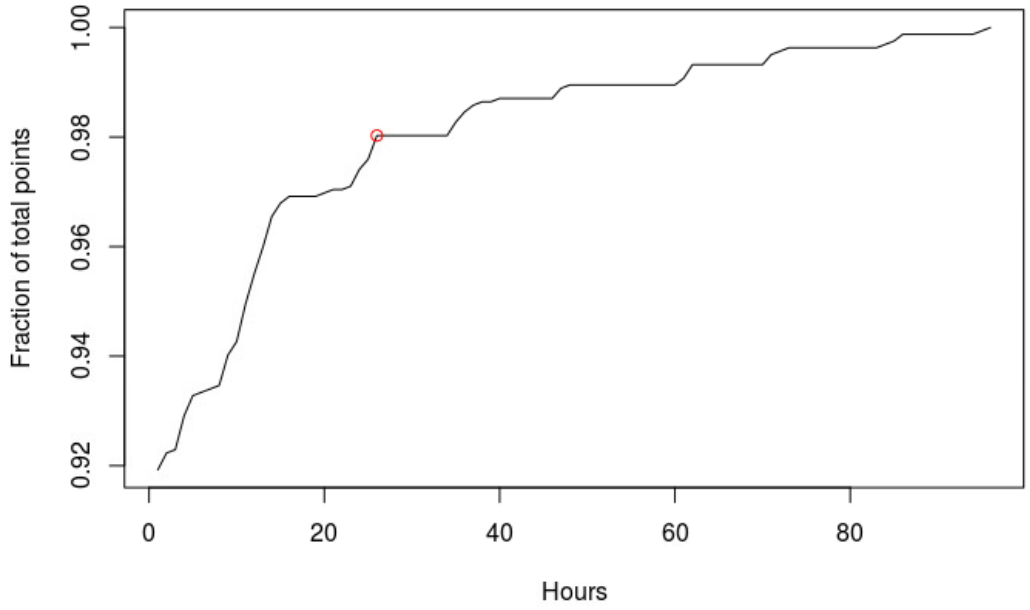
Methods: flowchart



Sensitivity analysis

- FRP products in Near Real-Time (NRT) mode may have a spatial displacement, due to approximated estimates of azimuth angle and satellite positioning, spatially collocating FRP points outside actual burned area polygons
- Burned area polygons may have been mapped using a change detection method from satellite imageries acquired few days after the fire took place, resulting in temporal information lagged from actual fire date
- Sensitivity analysis was performed to find best spatial buffer radius (range 0-2000 m) and time lag (range 0-96 h) values

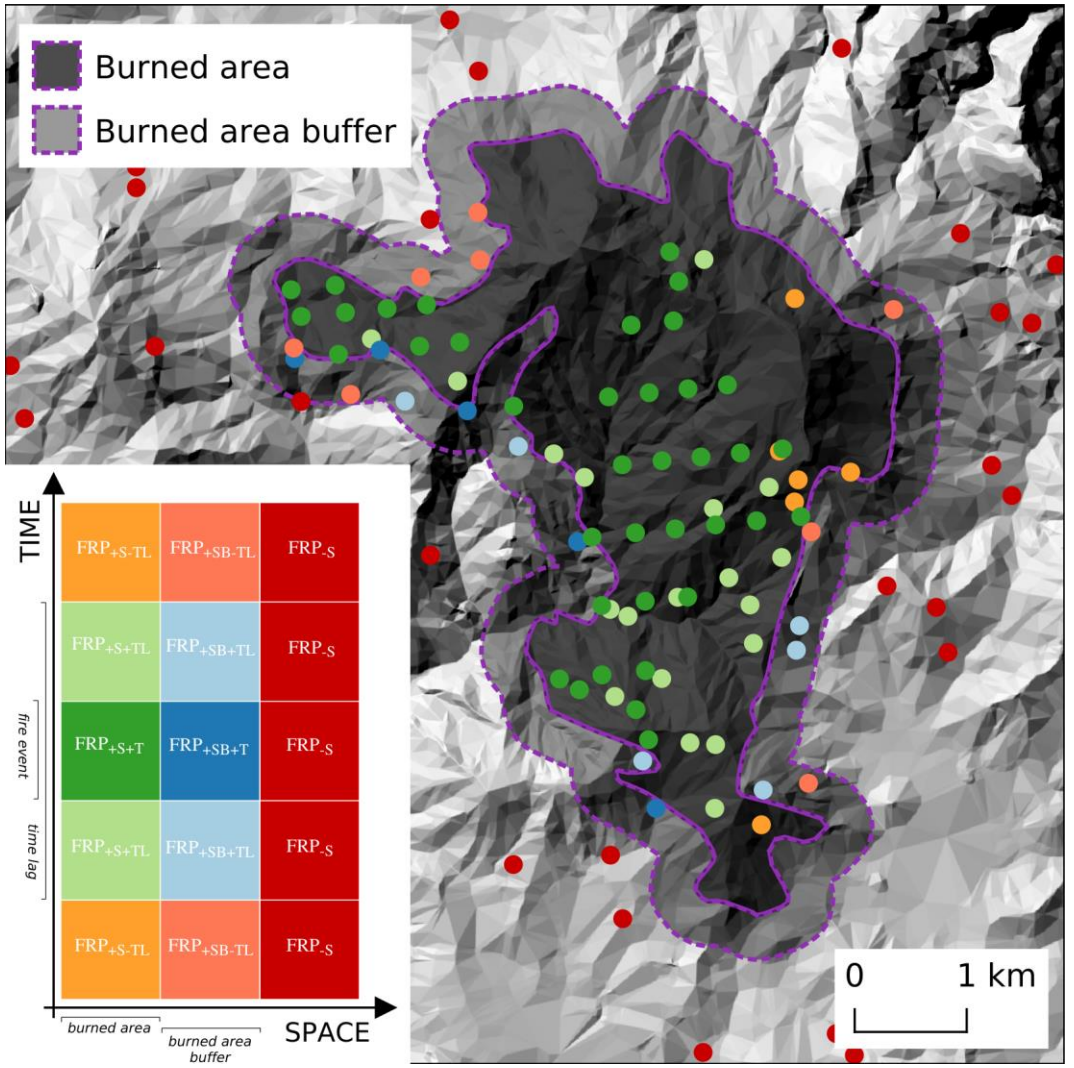




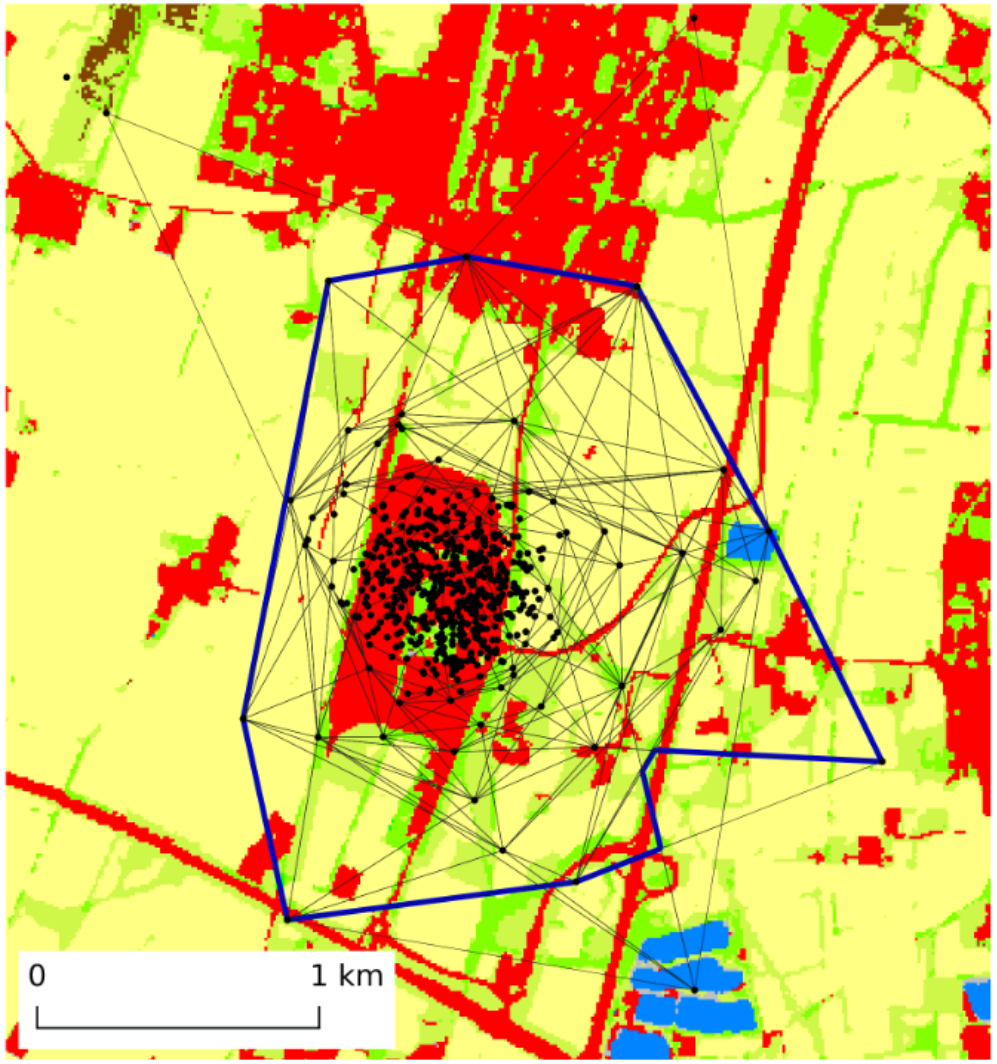
FRP points labelling

Class	Description	Count	Percentage
FRP_{-S}	Outside burned area polygon	42670	83.61
FRP_{+S-TL}	Inside burned area polygon, outside fire event time lag	329	0.64
FRP_{+S+T}	Inside burned area polygon, within fire event time range	2397	4.70
FRP_{+S+TL}	Inside burned area polygon, within fire event time lag	1590	3.12
FRP_{+SB-TL}	Inside burned area buffer polygon, outside fire event time lag	1590	1.17
FRP_{+SB+T}	Inside burned area buffer polygon, within fire event time range	1510	2.96
FRP_{+SB+TL}	Inside burned area buffer polygon, within fire event time lag	1939	3.80

First step used for clustering analysis consists in labelling each of the about 75000 FRP pixel points with a class. Space is the leading dimension used for FRP points labelling, each point is first checked as spatially residing within burned areas. Later, time information of burned areas, available from fields named 'FIREDATE' and 'LASTUPDATE' in BAD-ITE, is used to identify FRP points temporally occurred during each mapped fire event.

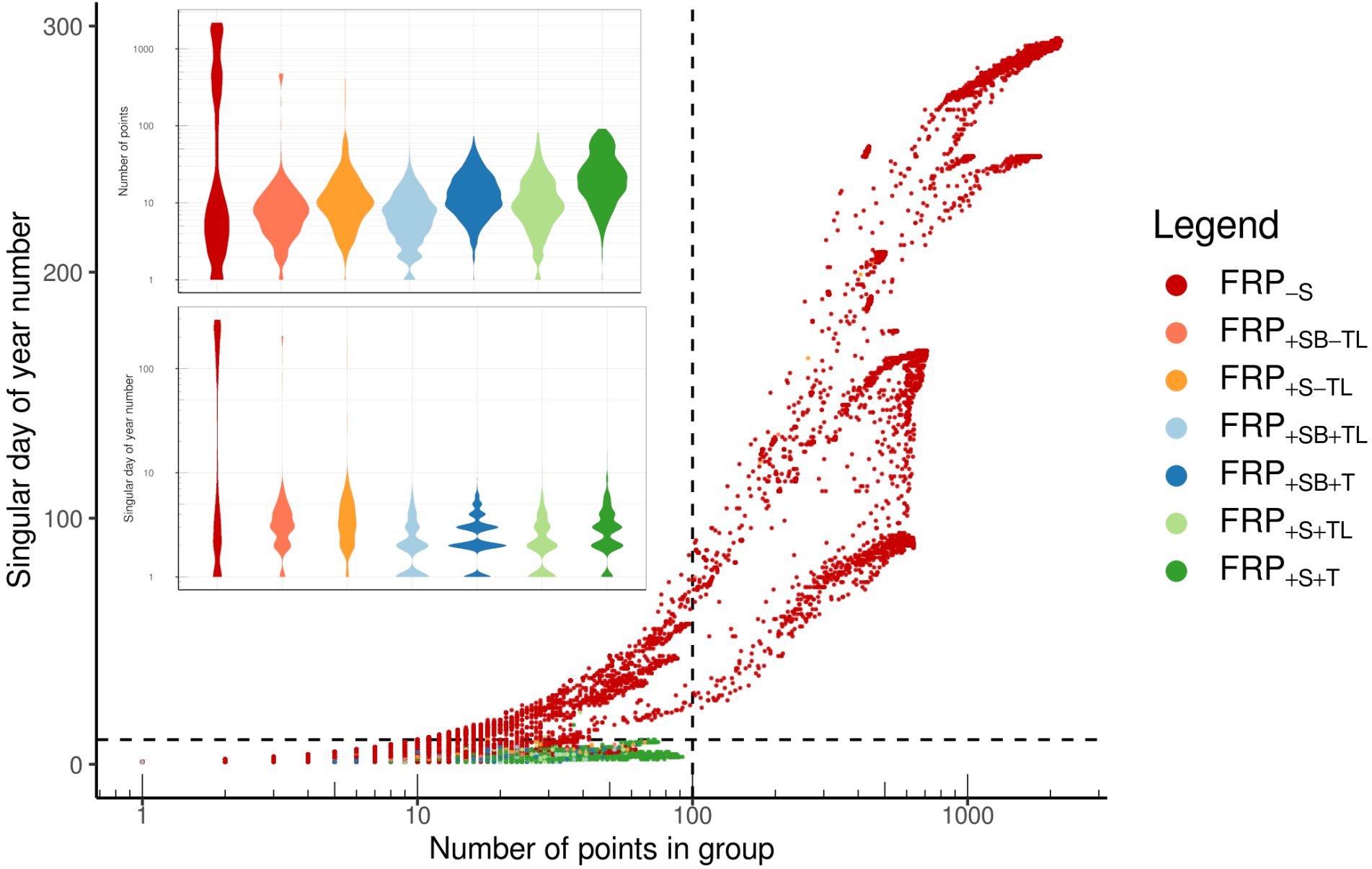


Thermal anomalies hotspots – Convex hulls analysis



For each variable, a threshold value was selected in order to spatially identify points clusters that can be considered thermal anomalies hotspots, misclassified as fire pixels. For each points cluster, the corresponding spatial convex hull has been generated. Only areas with more than 3 overlapping convex hull have been used to generate final hotspots polygons.

Results


Singular day of year number
300
200
100
0
1
10
100
1000
Number of points in group
Number of points
Singular day of year number
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FRP−S
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FRP+SB+TL
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FRP+S+TL
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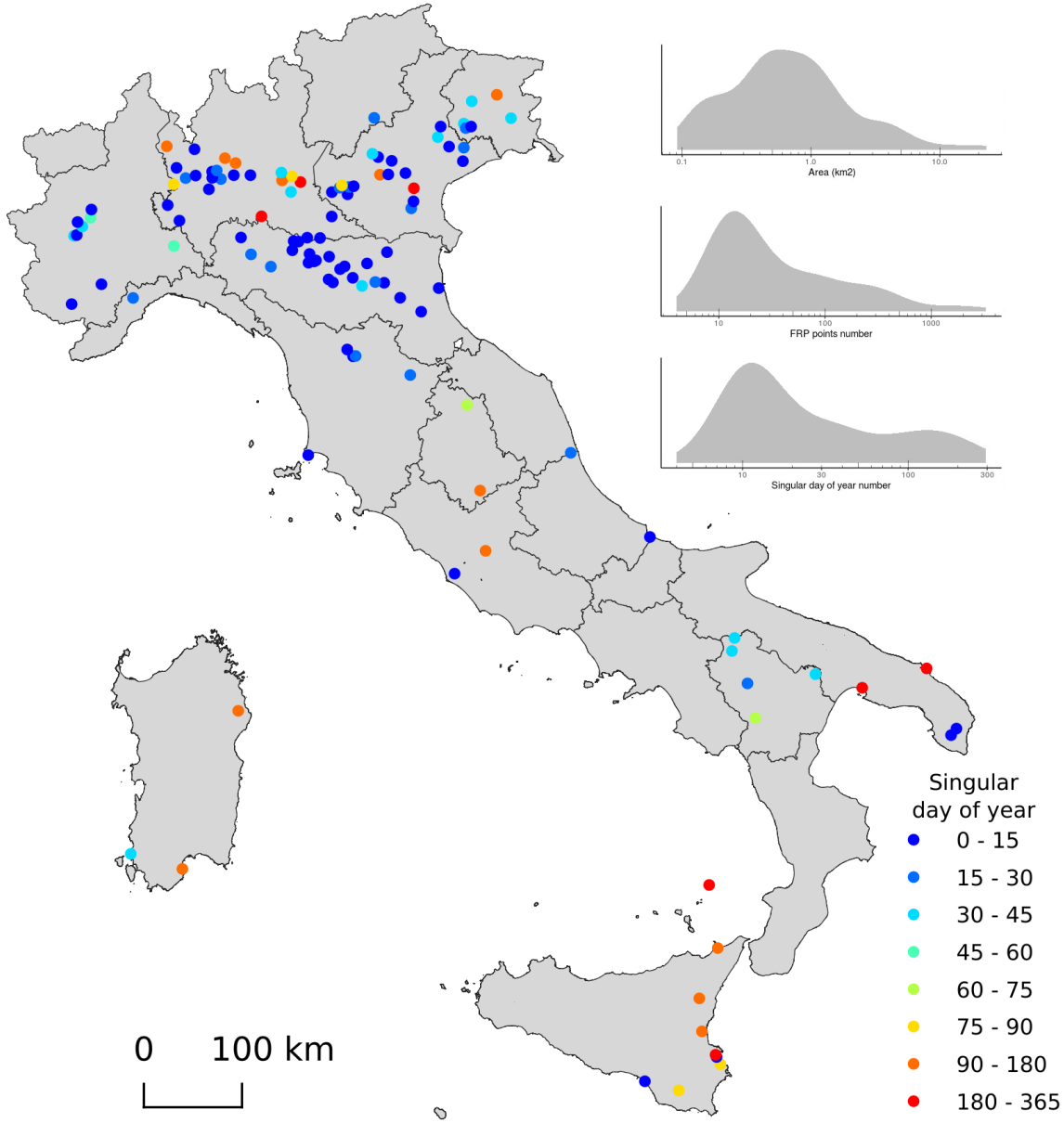
Results

Identified hotspots, although they are a small number and correspond to about 165 km^2 (0.05% of Italy national territory), allow the removal of about 40% misclassified FRP points

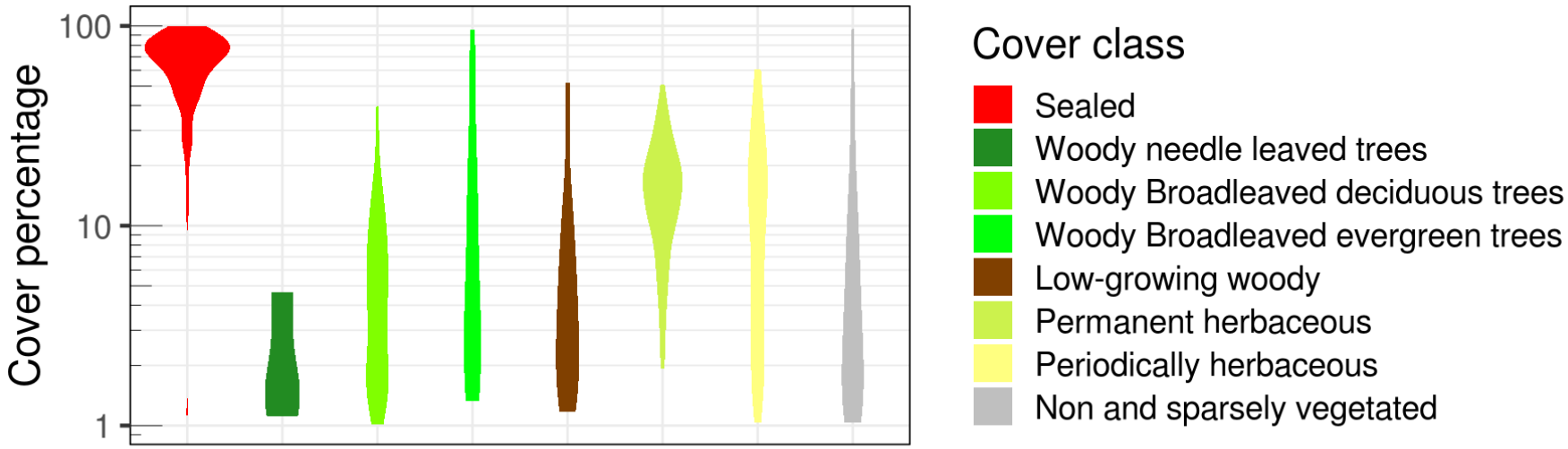


Results

Temporal period	FRP points number	Number of misclassified FRP points (FRP-S FRP+S-TL FRP+SB-TL)	Number of removed misclassified FRP points (FRP-S FRP+S-TL FRP+SB-TL)	Percentage of removed misclassified FRP points (FRP-S FRP+S-TL FRP+SB-TL)
01/01/2022 31/12/2022	51033	43597	16428	37.68
01/01/2022 31/07/2022	32732	27485	11637	42.34
01/01/2023 31/07/2023	23386	18817	7686	40.85

From spatial intersection between burned area polygons and FRP points, with corresponding spatial buffer and time lag, 79.01% of burned areas have a FRP point sensed by satellites during fire event in 2022. Comparison exercise from January 2023 – July 2023 acquisitions resulted in 77.88% of corresponding points (77.67% from the same year period in 2022).

Results



From a comparison with land cover classes, identified thermal anomalies hotspots are characterized by high cover percentage of sealed surface. From a visual inspection of geolocation of the hotspots, it has been possible to observe that they are mainly located in correspondence of industrial areas, metallurgical industries, cement factories, warehouses, and volcanoes.