The fully automated service of burned areas mapping in Italy based on Sentinel-2 and ancillary data

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Outline

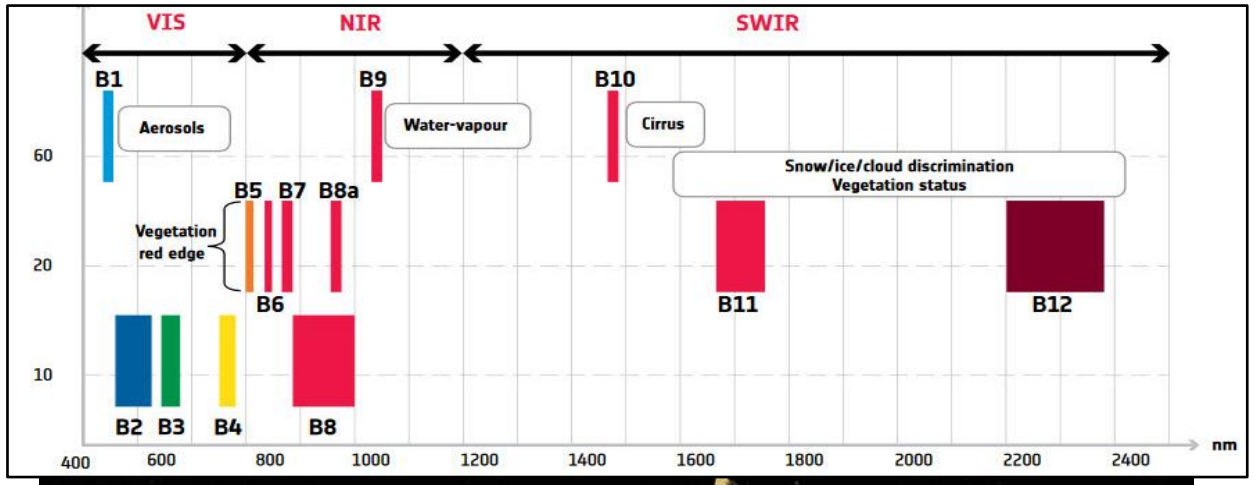
- The service
- The processor implementing the service
- Validation of the maps of burned areas

Characteristics & Requirements

- Continuous nationwide (Italy) monitoring of burned areas (BAs) using *multispectral data* provided by the Sentinel-2 (S2) constellation
  - Systematic processing of all daily S2 images of the Italian territory (*cloud cover < 40%)*
- Includes *S2 data download, processing and publishing* of the daily BA maps on the *MyDEWETRA* web-gis platform (all automated)
- Operational *365 days/year*
- Processing chain runs once a day at 00:00 to process images acquired the day before
- Spatial resolution of the BA maps: 20 m
- Minimum mapping unit: 1 ha

S2 coverage of Italy

- S2 is a multispectral imaging mission
  - 13 spectral bands →



- S2 constellation of 2 satellites allows for a revisit frequency of 5 days (under the same viewing conditions)
  - Overlap between swaths from adjacent orbits → revisit frequency may increase (different viewing conditions)
  - *Cloud cover* may imply longer revisit time

Some numbers….

- Service working *since 2019* (pre-operational mode)
- Italy covered with 73 tiles subdivided along 6 orbits
  - S2 products available as tiles of fixed size (100 × 100 km^2) along with a single orbit
- For each year, 1200-1500 S2 tiles (e.g., ~ 1300 in 2021) were processed (depending on the n° of tiles discarded due to clouds)
- During the 2019-2021 summer campaigns (fire season: June - September), *more than 4000 tiles were processed*

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The processor: AUTOBAM

- AUTOBAM (AUTOmatic Burned Areas Mapper) maps BA through a ***change detection*** approach
  - Applied to 3 spectral indices derived from S2 data
  - Carried out comparing the values of the indices at current time with the values derived from the most recent cloud-free S2 data
  - Implemented combining ***different processing techniques*** like clustering, edge filtering, adaptative buffering, automatic thresholding and region growing
- Among the available S2 data, ***level 2A products*** are used
  - Corrected for the effects of the atmosphere (surface reflectance ρ)
  - Include a scene classification map useful to ***mask clouds and water bodies***
- S2 data complemented by ***ancillary data***
  - MODIS-derived and VIIRS-derived hotspots (***active fires***)
  - fire notifications, from the firefighting fleet belonging to Joint Air Operating Centre (***COAU***)

AUTOBAM main steps (all automated)

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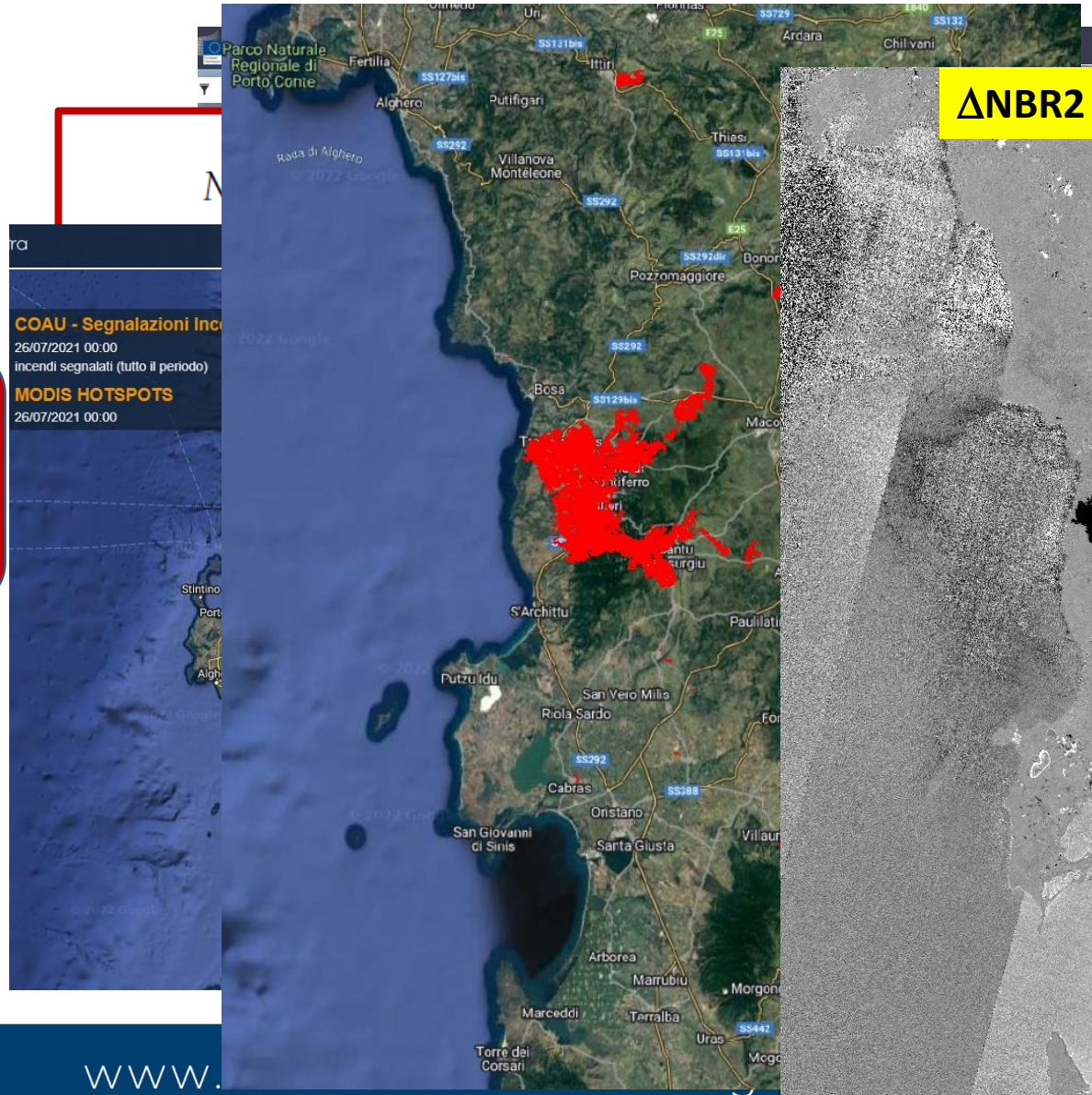
S2 data download

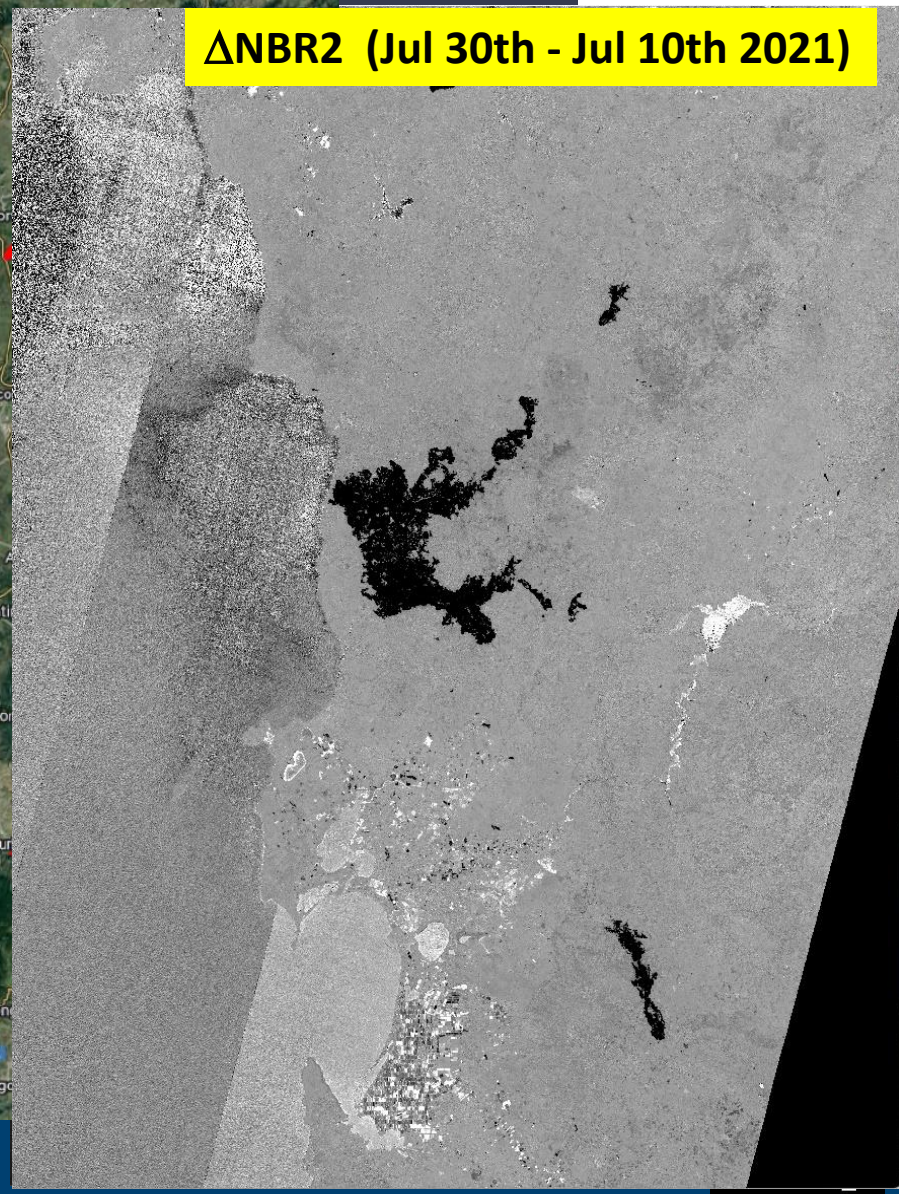
Computation of Spectral Indices (for for each tile)

Comparison with the values at previous time (most recent cloud free data)

Ingestion of Ancillary data

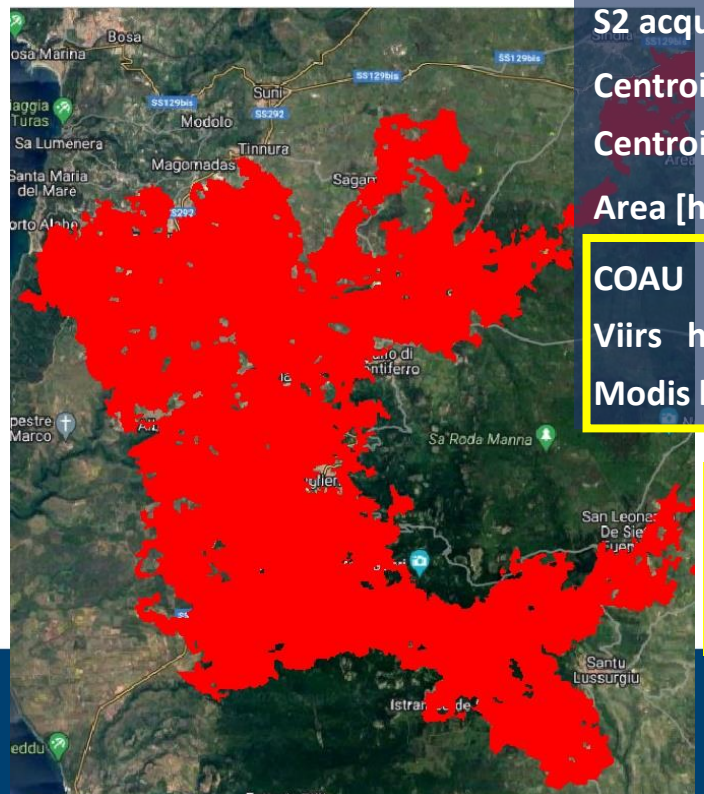
Generation of the BA maps





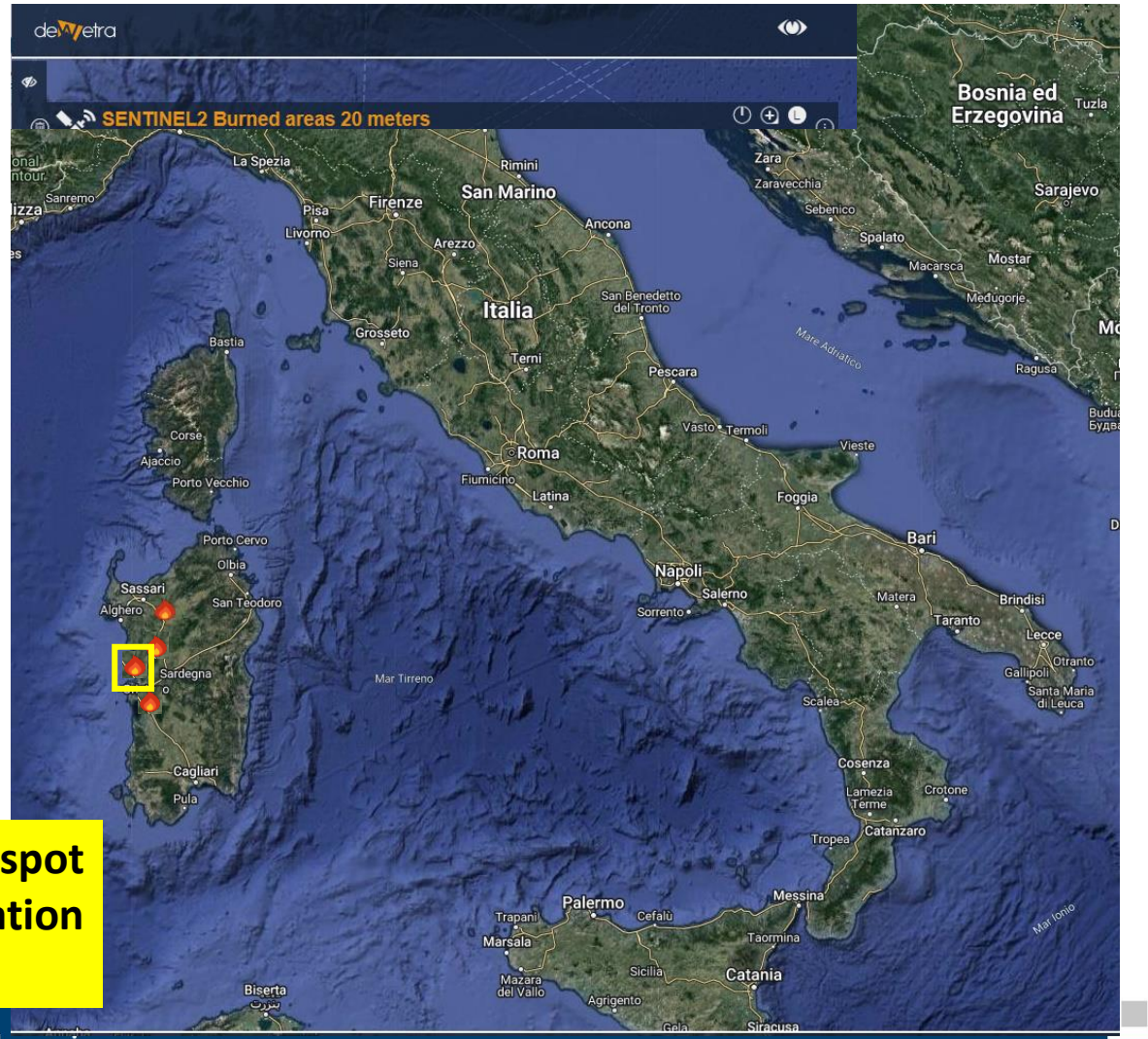
AUTOBAM output

- Mosaic of the BA maps produced for the different tiles
  - Raster (Geotiff)
  - Shapefile
- Maps published on the MyDewetra platform



S2 acquisition day	30/07/2022
Centroid X	8.55
Centroid Y	40.19
Area [ha]	12522.9
COAU	Yes
Viirs hotspot	Yes
Modis hotspot	Yes

Information whether a hostspot or a location of a fire notification is included in the BA



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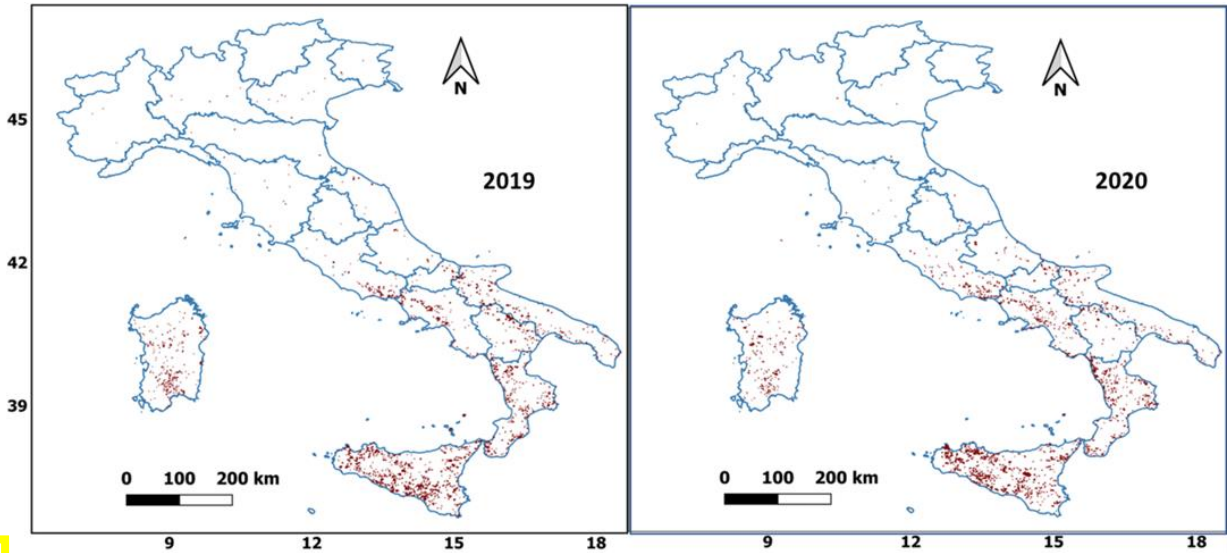
The BA database and the validation set

- AUTOBAM-derived BA database
  - Fire seasons 2019-2021 (June-September)
  - 2019: ~ 29000 [ha]
  - 2020: ~ 36000 [ha]
  - 2021: ~ 150000 [ha]
- Validation database
  - burn polygons provided by *Carabinieri* Command of Units for Forestry, Environmental and Agri-food protection and, for autonomous regions, by regional forestry corps
  - Available *some months after the fire season*



Official BA data for Italy

Validation exercises

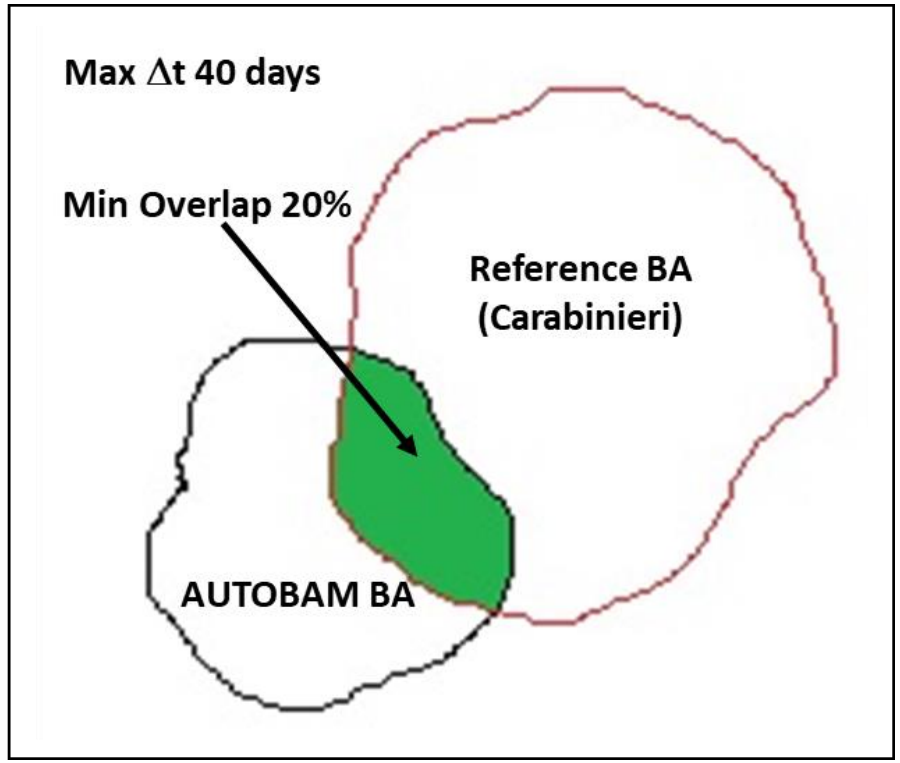
- Validation set includes information about
  - extent of each BA (in ha)
  - fire date

- Two validation exercises to evaluate:
  - BA *detection capability*
  - BA *mapping accuracy*

BA detection capability: procedure

- BA included in the validation set assumed as ***reference***
- A reference BA is considered as detected by AUTOBAM if all the following conditions are fulfilled:
  - $A_{overlap} / A_{ref} > 20\%$
  - $A_{overlap} / A_{AUTOBAM} > 20\%$
  - $\Delta t \leq 40$ days

Δt: difference between the S2 acquisition day and the fire date associated to each reference BA



BA detection capability: results

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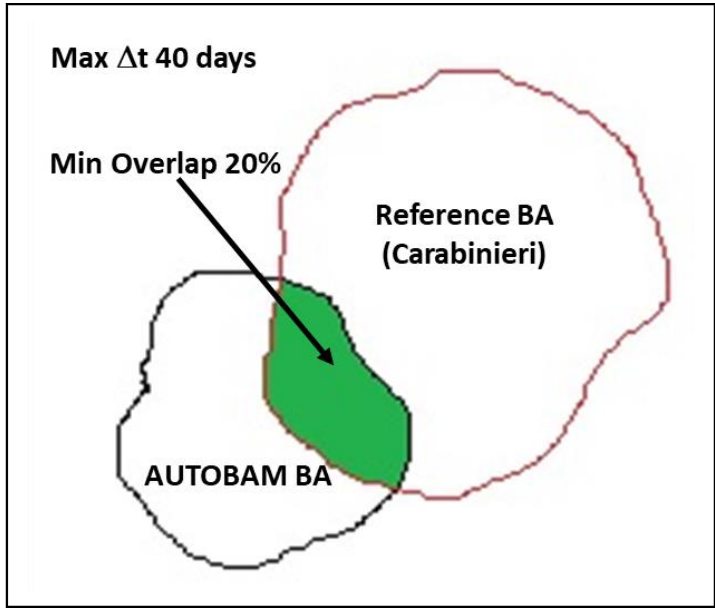
Detection count

year	N° Reference BAs	N° Detected BAs	N° Missed° BAs	Detected BAs %	Missed BAs %
2019	2117	1357	760	64.1	35.9
2020	1957	1201	756	61.4	38.6
2021	2923	1876	1047	64.2	35.8
2019-2021	6997	4434	2563	63.4	36.6

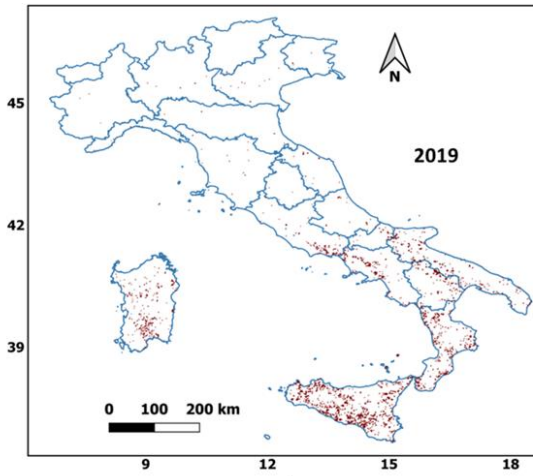


Total burned surface

year	Reference BAs [ha]	Detected BAs [ha]	Missed BAs [ha]	Overlapped BAs [ha]	Non-overlapped BAs [ha]	Overlapped BAs [%]	Non-overlapped Bas [%]
2019	34694.4	29069.6	6687.8	21637.5	13056.9	62.4	37.6
2020	42245.0	35786.5	8196.4	26736.7	15508.3	63.3	36.7
2021	147500.3	154754.1	18803.3	109284.6	38215.6	74.1	25.9
2019-2021	224439.7	219610.2	33687.5	157658.8	66780.9	70.2	29.8

BA mapping accuracy: evaluation

		Reference Class (CC)	
		Unburned	Burned
AUTOBAM Class	Unburned	A11	A21
	Burned	A12	A22



Accuracy metrics

$Dice\ Coefficient$	$DC = 100 \times \frac{2A22}{2A22 + A12 + A21}$	Ce and Oe combination (best value 100%)
$Commission\ Error$	$Ce = 100 \times \frac{A12}{A12 + A22}$	Measurement of false positives (best value 0 %)
$Omission\ Error$	$Oe = 100 \times \frac{A21}{A21 + A22}$	Measurement of false negatives (best value 0 %)
$Relative\ Bias$	$relB = \frac{A12 - A21}{A22 + A21}$	Indicates whether there is overestimation (positive) or underestimation (negative) of the APF (best value 0)

BA mapping accuracy: results

year		AUTOBAM
2019	*DC*	48.1
	Ce	61.2
	Oe	36.7
	RelB	63.1
2020	*DC*	58.4
	Ce	47.8
	Oe	36.1
	RelB	22.4
2021	*DC*	76.4
	Ce	27.9
	Oe	25.2
	RelB	3.8
2019 - 2021	*DC*	68.6
	Ce	39.0
	Oe	29.0
	RelB	16.4

To obtain the statistics of the BA by land cover type, the data from the CORINE Land Cover database were used

land cover		Forest	Shrubland
year			
2019 - 2021	*DC*	74.7	82.8
	Ce	19.3	12.8
	Oe	33.8	21.1
	relB	-18.0	-9.5

Main Critical Aspects

- Difficulties in detecting BAs in:
  - cropland
  - areas obscured by persistent cloud cover
  - areas hit by surface fires that do not impact the canopy

- AUTOBAM performances depend on the accuracy of the scene classification map included in the Sentinel-2 level 2A product, especially on the *reliability of the cloud detection*

Conclusions & Outlook

- AUTOBAM systematically processes all the S2 observations of Italy (cloud cover < 40%) to daily produce a BA map ***used by DPC and some regions in pre-operational mode***
- Good BA detection capability
  - > 60% in terms of detection count
  - ~ 70% in terms of estimation of ha of BA
- Possibility to carry out similar validation exercises for other kind of satellite-derived BA data too (ref. data provided by Italian authorities)
- Possibility to ingest other ancillary data to improve BA mapping accuracy
  - From 2021 (Lazio) and 2022 (Abruzzo), a couple of regions are providing AUTOBAM with accurate fire notifications derived from their SOUP (Italian acronym of Permanent Unified Operations Room)

Thank you for your attention

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