BAIS2: Burned Area Index for Sentinel-2

Federico Filipponi

federico.filipponi@gmail.com

Problem

Sentinel-2 satellites, equipped with MSI sensor with specific spectral bands to record data in the vegetation red-edge spectral domain, opened the way to the development and application of new spectral indices for discriminating burn severity

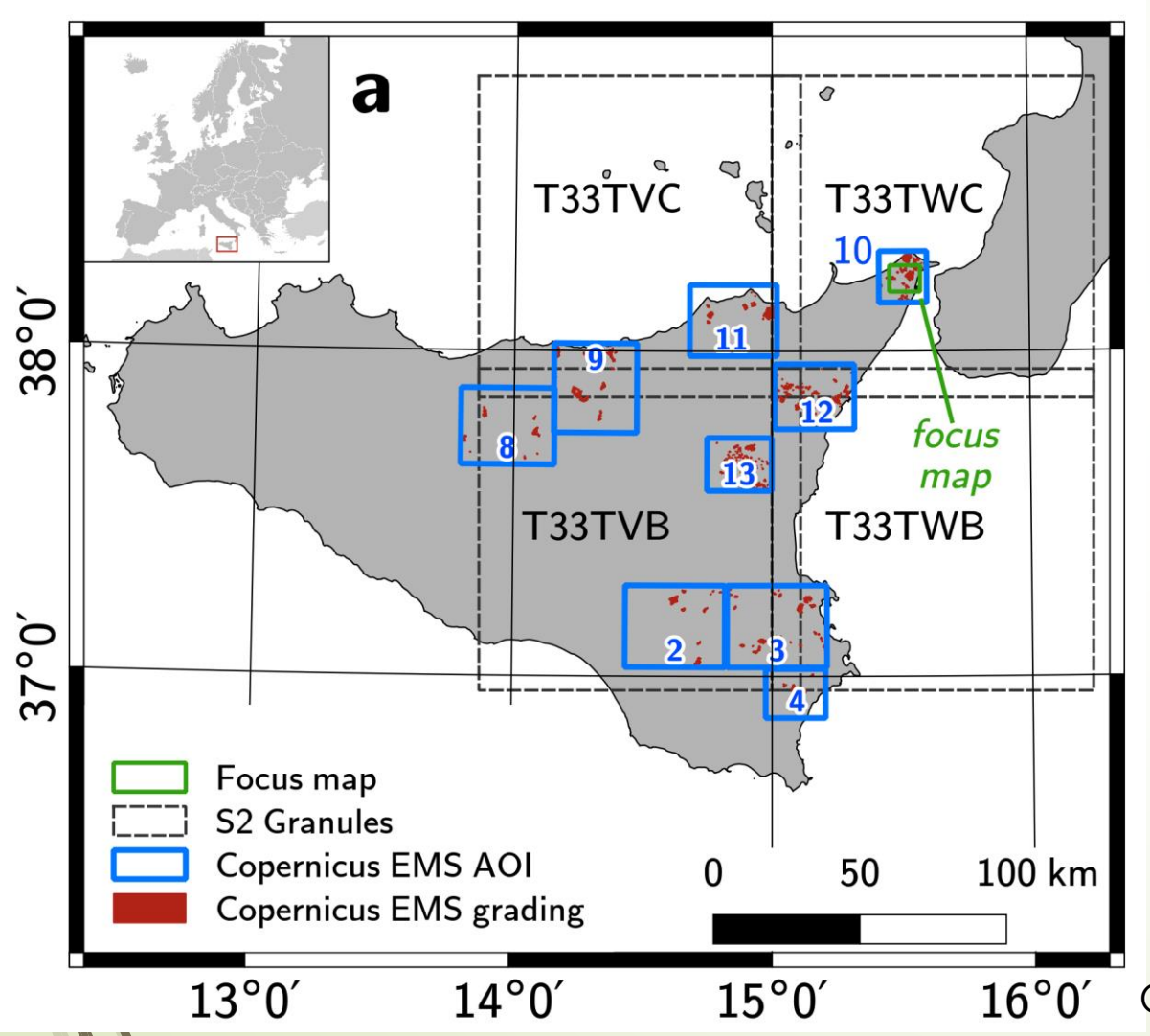
Need for further research to develop

a systematic S2 MSI burned area mapping capability

Proposal

- This study present the new **BAIS2** (Burned Area Index for Sentinel-2) spectral index for burned area mapping, specifically designed to take advantage of the S2 MSI spectral characteristics and adopting spectral combination of bands which have been demonstrated to be suitable for post-fire burned area detection.
- Derived **dBAIS2** index (Difference Burned Area Index for Sentinel-2) is based on the artihmetic difference between pre-fire BAIS2 and post-fire BAIS2 estimates.

Study area

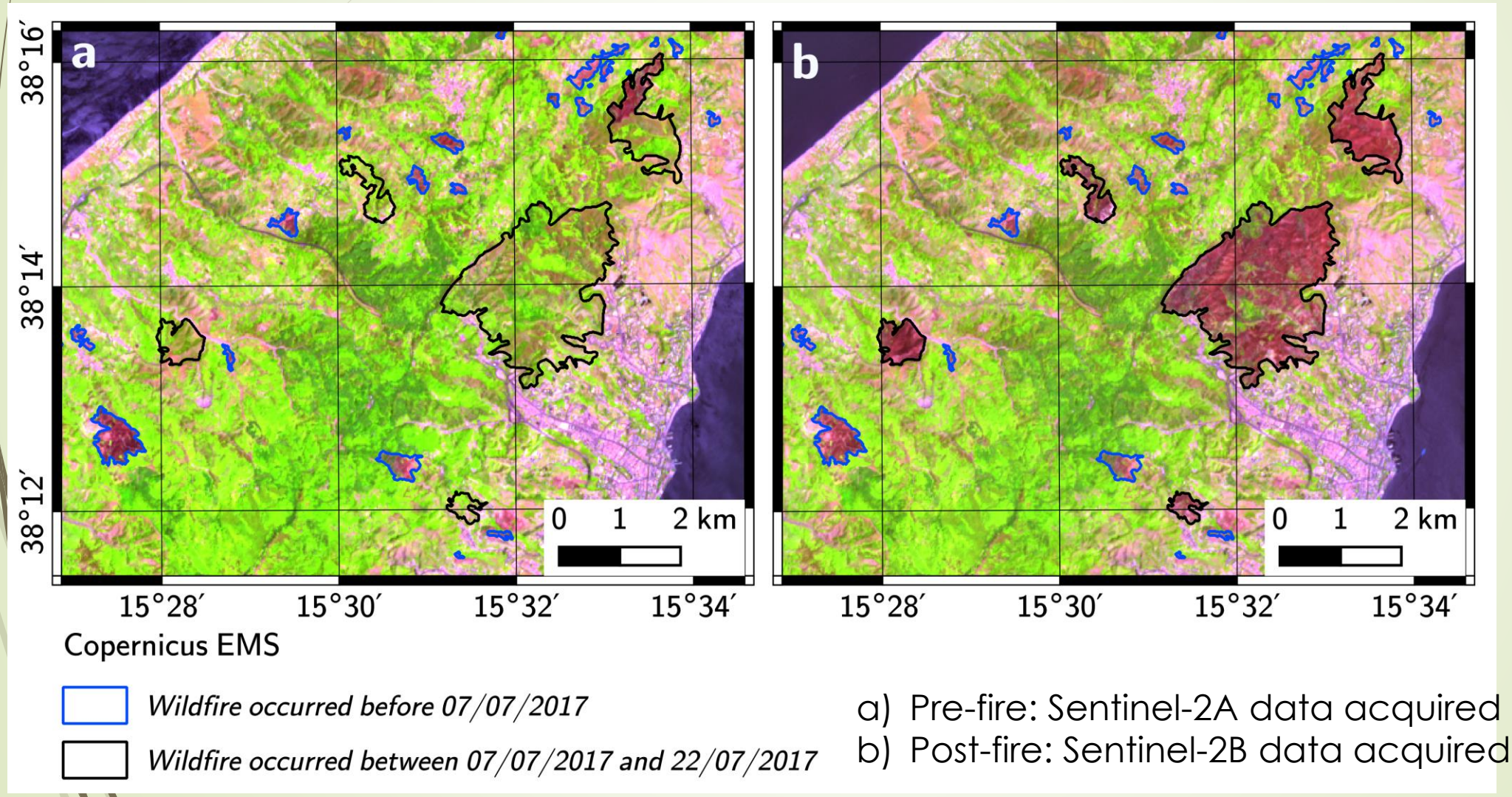


During summer 2017 in Sicily region (southern Italy), many wildfire burned 110.21 km^2 of land on a total of 5231.56 km^2 (source: Copernicus EMS)

Copernicus EMS grading map (ID: EMSR213) was used as reference truth

Contains modified Copernicus Service information [2017]

Sentinel-2 images



a) Pre-fire: Sentinel-2A data acquired on 07/07/2017
b) Post-fire: Sentinel-2B data acquired on 22/07/2017

Processing

- Atmospheric correction using Sen2cor
- Biophysical processor to estimate Leaf Area Index (LAI)
- Water Pixel (WP) mask using formula:

$$WP = \left(\frac{(B8A + B11 + B12) - (B01 + B02 + B03)}{(B8A + B11 + B12) + (B01 + B02 + B03)}\right) < 0$$

- Normalized Burned Ratio:

$$NBR = \frac{B8 - B12}{B8 + B12}$$

- Zonal statistics within the Copernicus EMS grading levels
- Spectral sensitivity using Separability Index:

$$SI = \frac{|\mu b - \mu u|}{(\sigma b + \sigma u)}$$

Burned Area Index for Sentinel-2

BAIS2 benefit from vegetation properties described in the red-edge spectral domains and the radiometric response in the SWIR spectral domain, largely recognized to be efficient in the determination of burned areas.

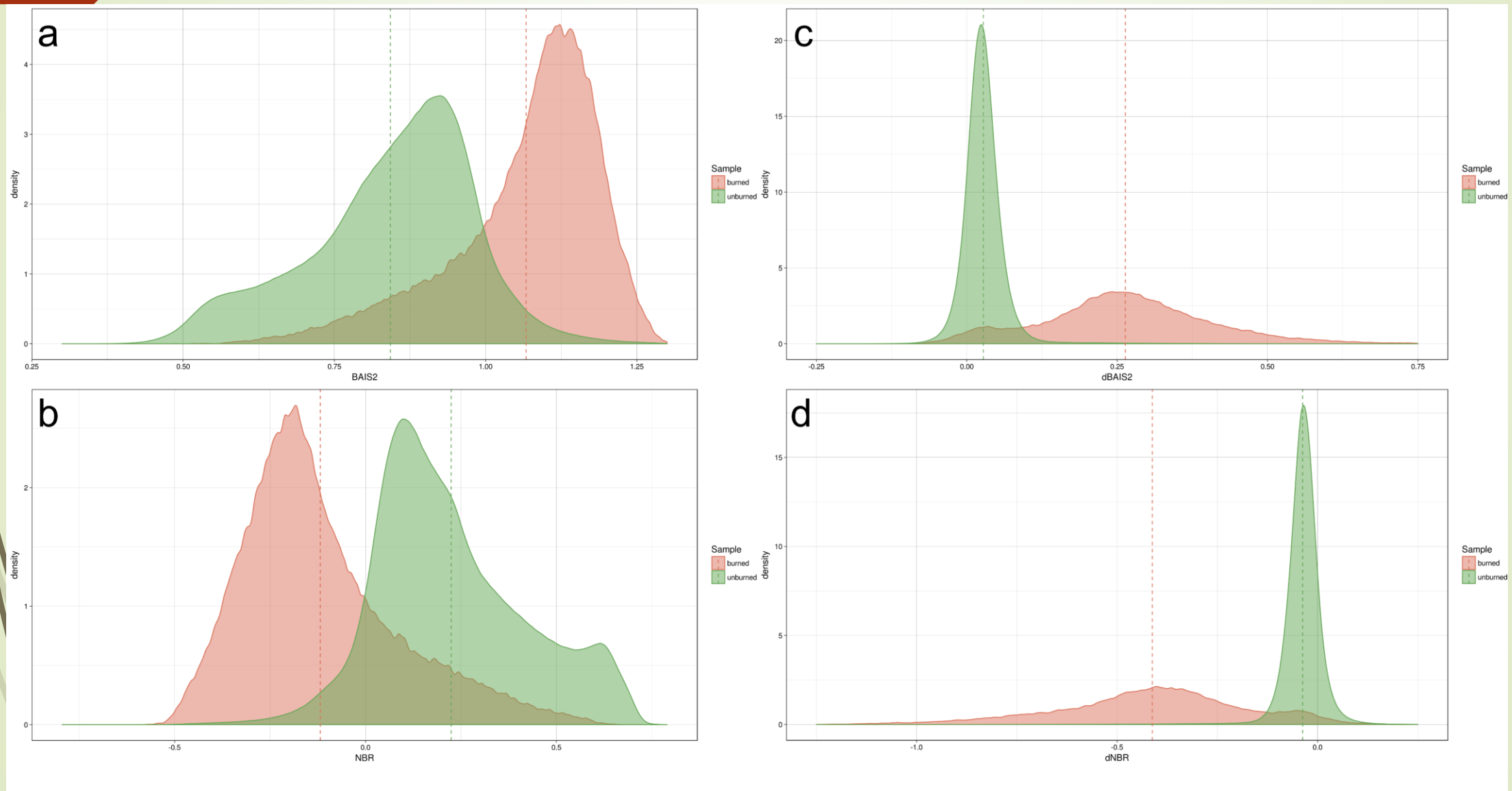
$$BAIS2 = \left(1 - \sqrt{\frac{B06 * B07 * B8A}{B4}}\right) * \left(\frac{B12 - B8A}{\sqrt{B12 + B8A}} + 1\right)$$

Results

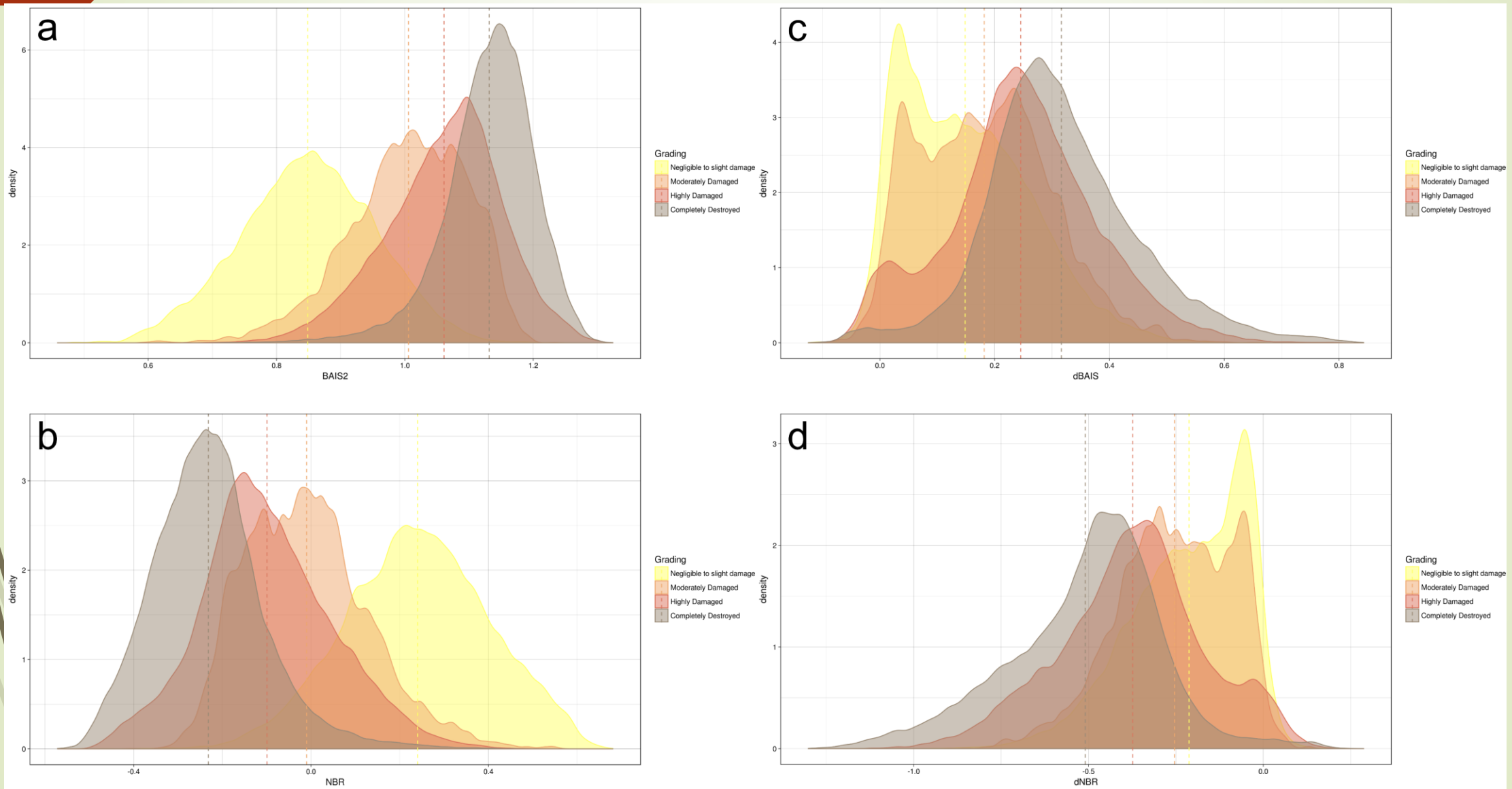
SI value of the 4 indices computed for the Copernicus EMS area of activations

BAIS2	NBR	dBAIS2	dNBR
0.865	0.848	1.337	1.324

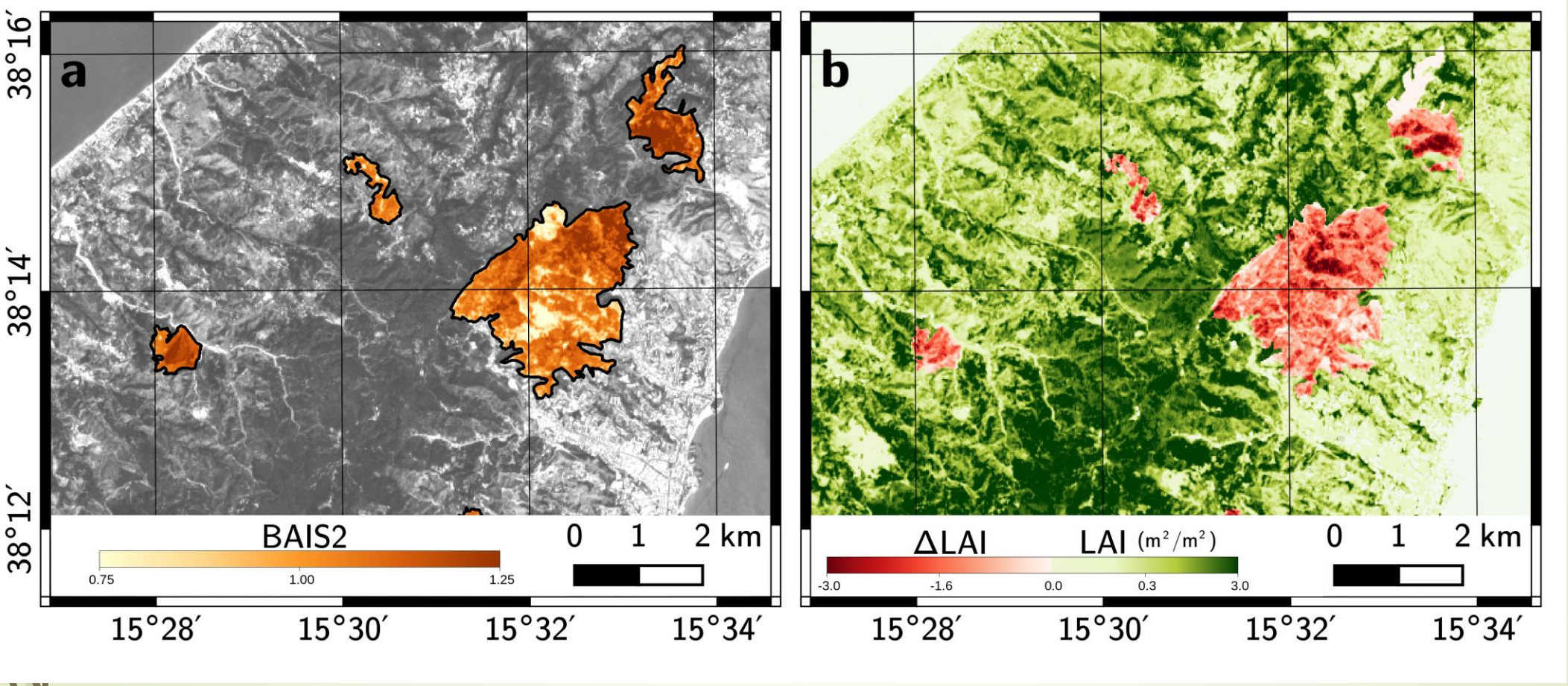
Results


a
density
BAIS2
0.25
0.50
0.75
1.00
1.25
0
1
2
3
4
b
density
NBR
-0.5
0.0
0.5
0
1
2
c
density
dBAIS2
-0.25
0.00
0.25
0.50
0.75
0
5
10
15
20
d
density
dNBR
-1.0
-0.5
0.0
0
5
10
15
Sample
burned
unburned

Results


a
density
BAIS2
0.6
0.8
1.0
1.2
0
2
4
6
Grading
Negligible to slight damage
Moderately Damaged
Highly Damaged
Completely Destroyed
c
density
dBAIS
0.0
0.2
0.4
0.6
0.8
0
1
2
3
4
Grading
Negligible to slight damage
Moderately Damaged
Highly Damaged
Completely Destroyed
b
density
NBR
-0.4
0.0
0.4
0
1
2
3
Grading
Negligible to slight damage
Moderately Damaged
Highly Damaged
Completely Destroyed
d
density
dNBR
-1.0
-0.5
0.0
0
1
2
3
Grading
Negligible to slight damage
Moderately Damaged
Highly Damaged
Completely Destroyed

Results



The difference between spectral indices and biophysical estimates suggests further investigation to identify the suitability of using biophysical estimates (i.e. LAI) for the evaluation of fire severity levels in a more comprehensive manner.

Lesson learned

Processing phase of S2 data highlighted critical issues related to the existence of extremely dark pixels that can be the source of errors in the classification of burned pixels from BAIS2 estimates.

In particular:

- a proper water area masking should be adopted, to remove the dark areas due to water spectrum absorption
- the cloud shadow pixels should be removed from image
- bidirectional reflectance distribution function (BRDF) should be minimized to enable reliable mapping of surface features, detection of surface change and to provide consistent sensor data comparison.

Under development…

Processor to be implemented as an operational service to support knowledge about wildfire occurrences profiting from fire severity estimation, loss of vegetation estimation and to monitor post-fire ecosystem responses