12TH EARSEL FOREST FIRES SIG WORKSHOP

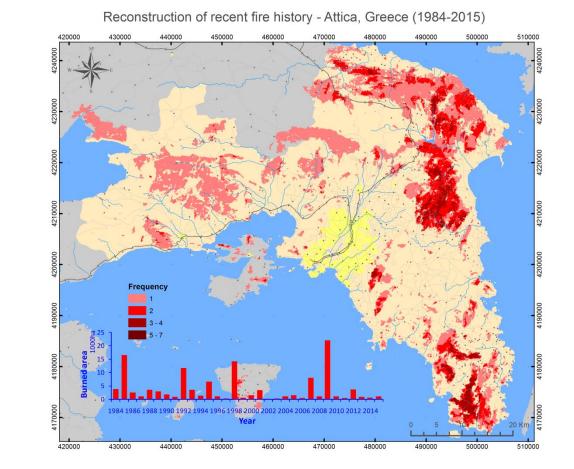
3-5 OCTOBER 2019, ROME, ITALY

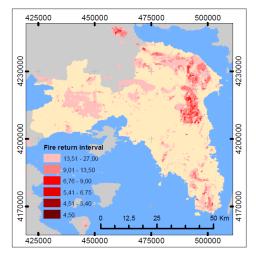
A rule-based semi-automatic method to map burned areas using Landsat and Sentinel-2 images – revisited and improved

Nikos Koutsias and Magdalini Pleniou

University of Patras, Department of Environmental Engineering, Greece

Maps of burned areas are important for various reasons

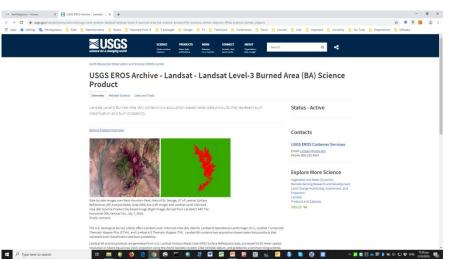




There are various products of burned areas but most are at global scale



However, recently USGS started providing the Landsat Level-3 Burned Area (BA) Science Product but only for US



Thousands of images

We need automatic techniques

International Journal of Remote Sensing, 2013 Vol. 34, No. 20, 7049–7068, http://dx.doi.org/10.1080/01431161.2013.816452



A rule-based semi-automatic method to map burned areas: exploring the USGS historical Landsat archives to reconstruct recent fire history

Nikos Koutsias^a*, Magdalini Pleniou^a, Giorgos Mallinis^b, Foula Nioti^a, and Nikolas I. Sifakis^{c,d}

^aDepartment of Environmental and Natural Resources Management, University of Ioannina, GR-30100 Agrinio, Greece; ^bDepartment of Forestry & Management of the Environment and Natural Resources, Democritus University of Thrace, GR-68200 Orestiada, Greece; ^cInstitute for Space Applications and Remote Sensing, National Observatory of Athens, GR-15236 Pendeli, Greece; ^dEuropean Research Council Research Agency, Brussels, Belgium

(Received 13 June 2012; accepted 3 March 2013)

Rule .	Arith	metic	expre	ession
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Description

If Landsat TM4 post < Landsat TM5 post then 1 (burned) otherwise 0 (unburned)

(unburned)

(unburned)

Ist rule

rule

 2^{nd}

rule

3"d

4th rule

rule

2"

multi-temporal rules

rules

uni-temporal

The reflectance of burned areas in the near-infrared band (e.g. TM4 in Landsat-5 or -7) is less than that in short-wave infrared band (e.g. TM5 in Landsat-5 or -7). However, for many other land-cover types (mainly the vegetated ones), their reflectance in near infrared band is higher than that in short-wave infrared band. Therefore, this rule differentiates burned areas with special emphasis on vegetated areas. The reflectance of burned areas in the short-wave infrared band (e.g. TM7 in Landsat-5 or -7) plus an additional threshold value If Landsat TM5 post < (a in 0.10-0.25) is slightly higher than that in short-wave Landsat TM7 post + ainfrared band (e.g. TM5 in Landsat-5 or -7), while for other land Landsat TM7 post then cover types their reflectance in short-wave infrared band (e.g. 1 (burned) otherwise 0 TM7 in Landsat-5 or -7) is lower than in short-wave infrared

band (e.g. TM5 in Landsat-5 or -7). Therefore, this rule differentiates burned areas with special emphasis on various land cover types and more specifically to vegetated areas.

The reflectance of sea water in the red band (e.g. TM3 in If Landsat TM3 post > Landsat-5 or -7) is less than that in blue band (e.g. TM1 in Landsat-5 or -7), while for many other land cover types Landsat TM1 post then including the burned areas, their reflectance in red is higher 1 (burned) otherwise 0 than in blue. Therefore, this rule differentiates burned areas with special emphasis on water bodies.

The reflectance of burned areas in the near infrared band (e.g. If TM4 post + a TM4 TM4 in Landsat-5 or -7) in the post-fire image is lower than that of the pre-fire image. An additional threshold value should be post < TM4 pre then 1 (burned) otherwise 0 defined (a in 0.10-0.25), otherwise features having even a 1 DN (unburned) value difference between the pre- and post-fire image are captured as changed.

The reflectance of burned areas in the mid infrared band (e.g. If TM7 post > TM7 pre TM7 in Landsat-5 or -7) in the post-fire image is higher compared to the pre-fire image. An additional threshold value + a TM7 pre then 1(burned) otherwise 0 should be defined (a in 0.10-0.25), otherwise features having even a 1 DN value difference between the pre- and post-fire (unburned) image are captured as changed.

Only post-fire image

1st rule

TM4 post<TM5 post

2nd rule

TM5 post<TM7 post+threshold

3rd rule

TM3 post>TM1 post

Pre- and post-fire image

4th rule

TM4 post+threshold<TM4 pre

5th rule

TM7 post>TM7 pre+threshold

Old set of rules

Expression

Rul

lst rule

2nd rule

3nd rule

4th rule

5th rule

uni-temporal rules

multi-temporal rules

Application

If Landsat TM4 post < Landsat TM5 post then 1 (burned) otherwise 0 (unburned)



If Landsat TM5 post < Landsat TM7 post + a Landsat TM7 post then 1 (burned) otherwise 0 (unburned) a=0.10-0.25



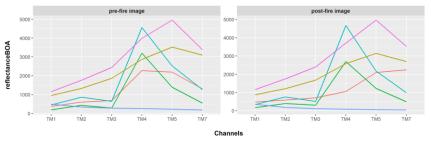
If Landsat TM3 post > Landsat TM1 post then 1 (burned) otherwise 0 (unburned)

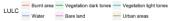
If TM4 post + a TM4 post < TM4 pre then 1 (burned) otherwise 0 a=0.10-(unburned) 0.25

If TM7 post > TM7 pre + a TM7 pre then 1 (burned) otherwise 0 (unburned) a=0.10-0.25

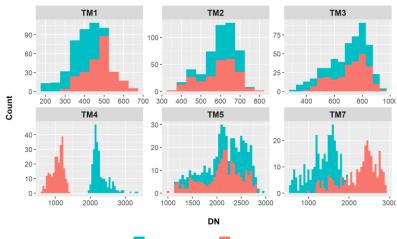


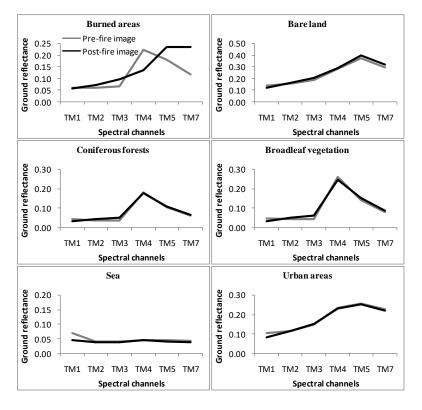
Italy - Landsat



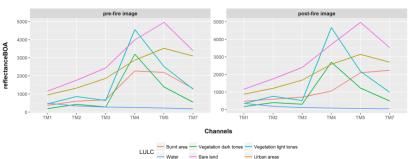


Italy - Landsat

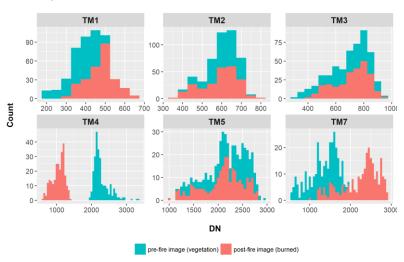








Italy - Landsat

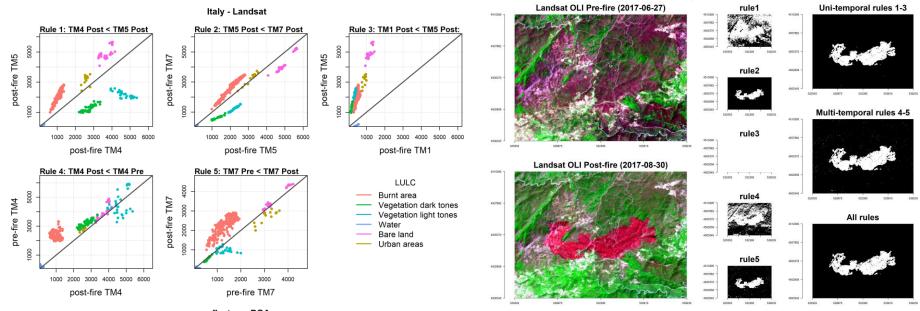


		Kul	Old set of rules		
Only post-fire image		е	Expression	Application	
1 st rule TM4 post <tm5 post<="" td=""><td></td><td>If Landsat TM4 post < Landsat TM5 post then</td><td></td></tm5>			If Landsat TM4 post < Landsat TM5 post then		
		i st rule	1 (burned) otherwise 0 (unburned)		
2 nd rule	l rules	I,	If Landsat TM5 post < Landsat TM7 post + a	5-5) (2-5)	
TM5 post <tm7 post+threshold<="" td=""><td>uni-temporal rules</td><td>le</td><td>Landsat TM7 post then 1 (burned) otherwise 0 (unburned) a=0.10-</td><td></td></tm7>	uni-temporal rules	le	Landsat TM7 post then 1 (burned) otherwise 0 (unburned) a=0.10-		
3 rd rule	Ē	2 nd rule	0.25		
TM3 post>TM1 post		le	If Landsat TM3 post > Landsat TM1 post then 1 (burned) otherwise 0		
Pre- and post-fire image		3 nd rule	(unburned) If TM4 post + a TM4		
4 th rule TM4 post+threshold <tm4 pre<="" td=""><td rowspan="2">4th rule</td><td rowspan="2">post < TM4 pre then 1 (burned) otherwise 0 (unburned) a=0.10- 0.25 If TM7 post > TM7 pre</td><td></td></tm4>		4 th rule	post < TM4 pre then 1 (burned) otherwise 0 (unburned) a=0.10- 0.25 If TM7 post > TM7 pre		
5 th rule	multi-temporal rules		+ a TM7 pre then 1 (burned) otherwise 0		
TM7 post>TM7 pre+threshold		5 th rule	(unburned) a=0.10- 0.25	N. MARKEN	

Rul

A successful example

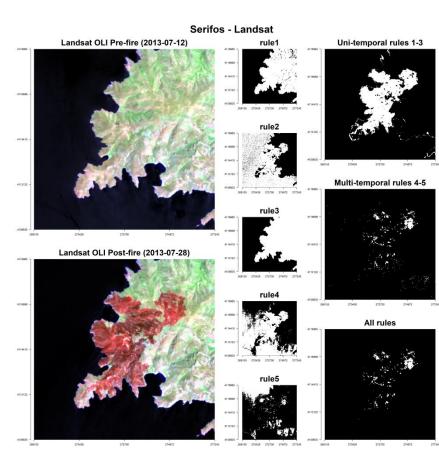
reflectanceBOA



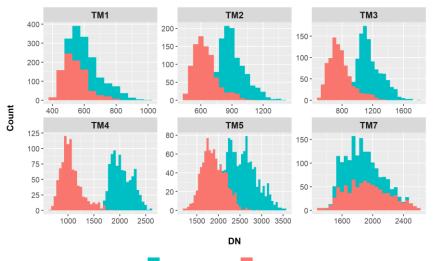
Italy - Landsat

reflectanceBOA

A non-successful example

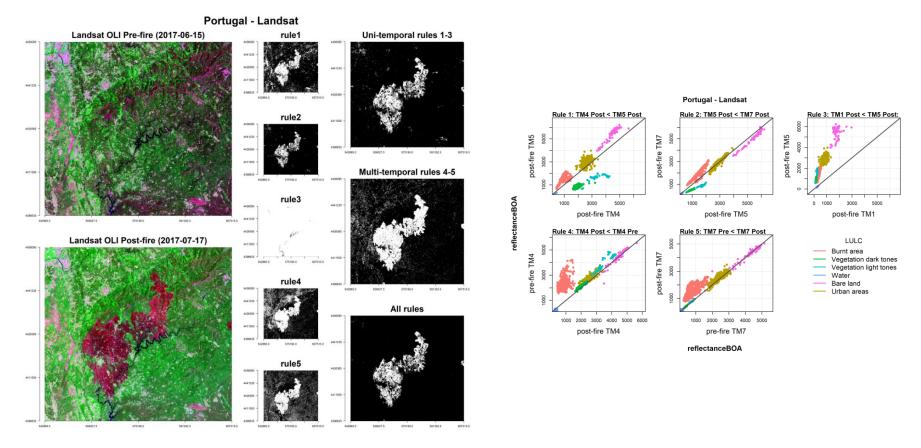


Serifos - Landsat



pre-fire image (vegetation) post-fire image (burned)

A non-successful example



	Now out of miles	Rul	Old set of rules		New set	
Old set of rules	New set of rules		Expression	Application	Expression	
Only post-fire image	Only post-fire image		If Landsat TM4 post <		If Landsat TM4 post <	
1 st rule	1 st rule	^a rule	Landsat TM5 post then 1 (burned) otherwise 0 (unburned)		Landsat TM5 post then 1 (burned) otherwise 0 (unburned)	
TM4 post <tm5 post<="" td=""><td>TM4 post<tm5 post<="" td=""><td>rules</td><td>If Landsat TM5 post < Landsat TM7 post + a</td><td></td><td>If Landsat TM5 post < Landsat TM7 post + a</td></tm5></td></tm5>	TM4 post <tm5 post<="" td=""><td>rules</td><td>If Landsat TM5 post < Landsat TM7 post + a</td><td></td><td>If Landsat TM5 post < Landsat TM7 post + a</td></tm5>	rules	If Landsat TM5 post < Landsat TM7 post + a		If Landsat TM5 post < Landsat TM7 post + a	
2 nd rule thres=0.25	2 nd rule thres=0.35	uni-temporal rules 2 nd rule	Landsat TM7 post then 1 (burned) otherwise 0 (unburned) a=0.10- 0.25		Landsat TM7 post + a Landsat TM7 post then 1 (burned) otherwise 0 (unburned) a=0.35	
TM5 post <tm7 post+threshold<="" td=""><td>TM5 post<tm7 post+threshold<="" td=""><td></td><td>If Landsat TM3 post ></td><td></td><td>If Landsat TM5 post ></td></tm7></td></tm7>	TM5 post <tm7 post+threshold<="" td=""><td></td><td>If Landsat TM3 post ></td><td></td><td>If Landsat TM5 post ></td></tm7>		If Landsat TM3 post >		If Landsat TM5 post >	
3 rd rule	3 rd rule	3 nd rule	Landsat TM1 post then 1 (burned) otherwise 0 (unburned)		Landsat TM1 post then 1 (burned) otherwise 0 (unburned)	
TM3 post>TM1 post	TM <mark>5</mark> post>TM1 post		If TM4 post + a TM4 post < TM4 pre then 1 (burned) otherwise 0		If TM4 post + a TM4 post < TM4 pre then 1	
Pre- and post-fire image	Pre- and post-fire image	multi-temporal rules 4 th rule	(unburned) a=0.10- 0.25		(burned) otherwise 0 (unburned) a=0.2 If TM7 post > TM7 pre	
4 th rule thres=0.10-0.25	4 th rule thres=0.05	multi-terr	If TM7 post > TM7 pre + a TM7 pre then 1 (burned) otherwise 0 (unburned) a=0.10-		+ a TM7 pre or lf TM5 post+ a TM5 post < TM5 pre then 1	
TM4 post+threshold <tm4 pre<="" td=""><td>TM4 post+threshold<tm4 pre<="" td=""><td>5th rule</td><td>0.25 Pre-fire image</td><td>Post-fire image</td><td>(burned) otherwise 0 (unburned) a=0.05 Old set of rules</td></tm4></td></tm4>	TM4 post+threshold <tm4 pre<="" td=""><td>5th rule</td><td>0.25 Pre-fire image</td><td>Post-fire image</td><td>(burned) otherwise 0 (unburned) a=0.05 Old set of rules</td></tm4>	5 th rule	0.25 Pre-fire image	Post-fire image	(burned) otherwise 0 (unburned) a=0.05 Old set of rules	
5 th rule thres=0.10-0.25 TM7 post>TM7 pre+threshold	5 th rule thres=0.05 TM7 post>TM7 pre+threshold TM5 post+threshold <tm5 pre<="" td=""><td>An example</td><td>Lender (3) Prode (1939-03)</td><td>Lender Of Parls (PH 1-9)</td><td></td></tm5>	An example	Lender (3) Prode (1939-03)	Lender Of Parls (PH 1-9)		

New set of rules

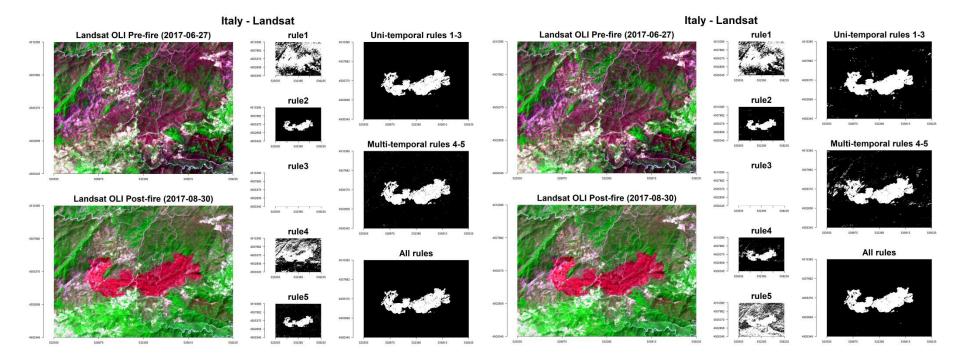
1

New set of rules

Application

Applying the new set of rules to the previous examples

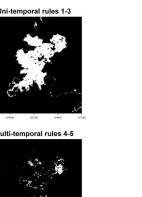
Old set of rules

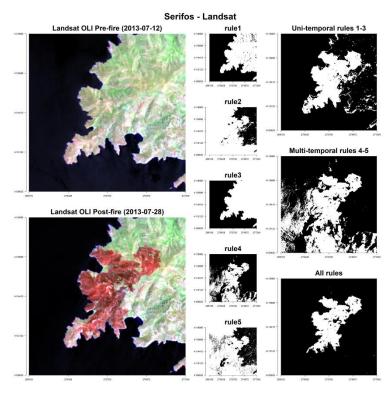


Applying the new set of rules to the previous examples

Serifos - Landsat Uni-temporal rules 1-3 Landsat OLI Pre-fire (2013-07-12) rule1 rule2 Multi-temporal rules 4-5 Landsat OLI Post-fire (2013-07-28) rule4 272700 All rules

Old set of rules

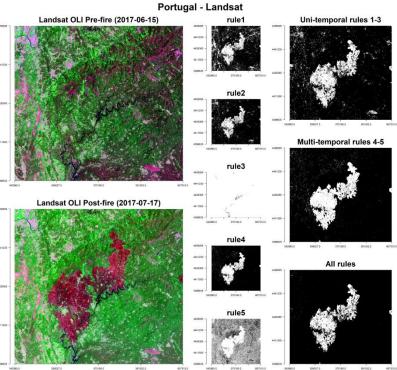




Applying the new set of rules to the previous examples

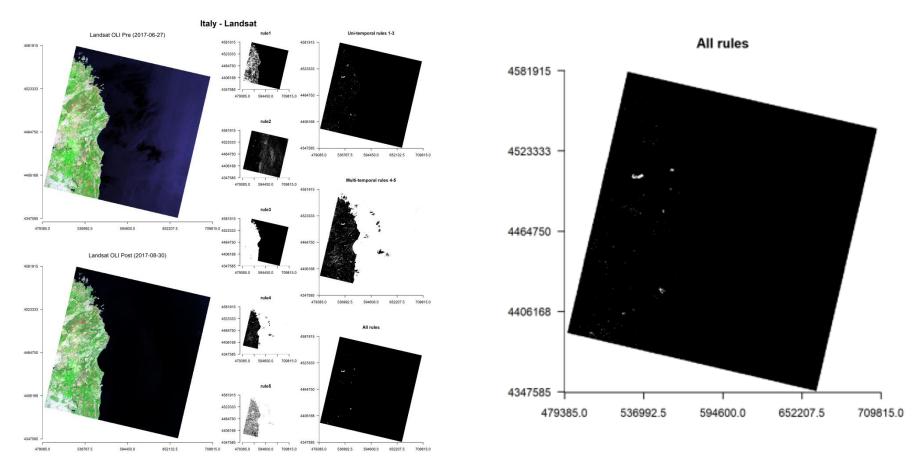
Portugal - Landsat Uni-temporal rules 1-3 Landsat OLI Pre-fire (2017-06-15) rule1 rule2 109027.5 273190.0 101312.5 Multi-temporal rules 4-5 rule3 Landsat OLI Post-fire (2017-07-17) 525190.0 641352.5 542965.0 5590227.5 All rules A76190.0 807515.0 542885.0 559027.5 575190.0 551352.5 817515.0

Old set of rules



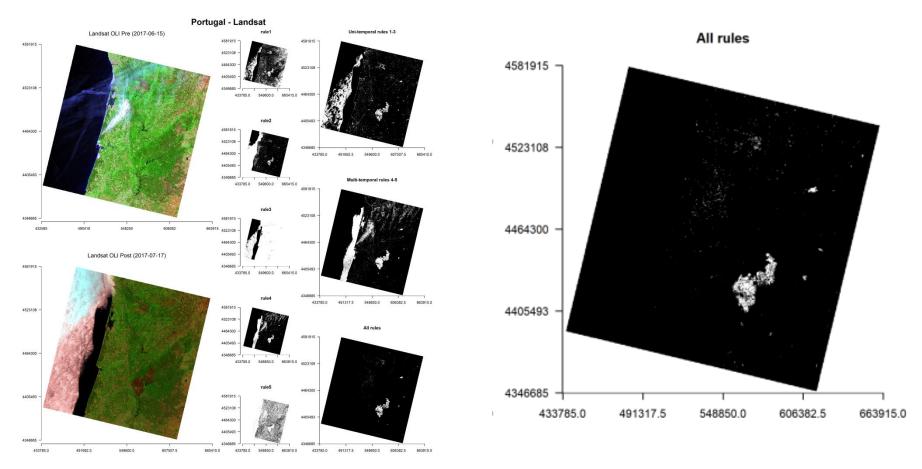
New set of rules

Applying the new set of rules to the whole image

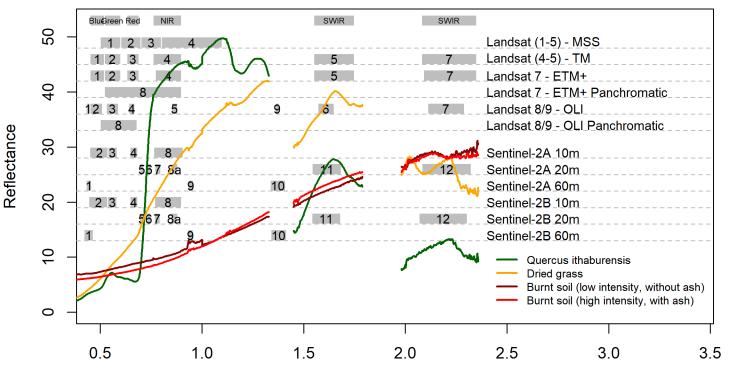


New set of rules

Applying the new set of rules to the whole image

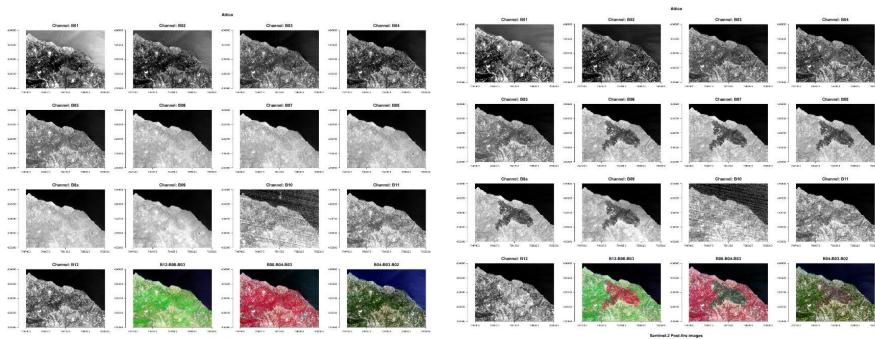


Spectral resolution of Sentinel-2 & Landsat satellites



Wavelength (micrometers)

Applying the new set of rules to Sentinel-2 images

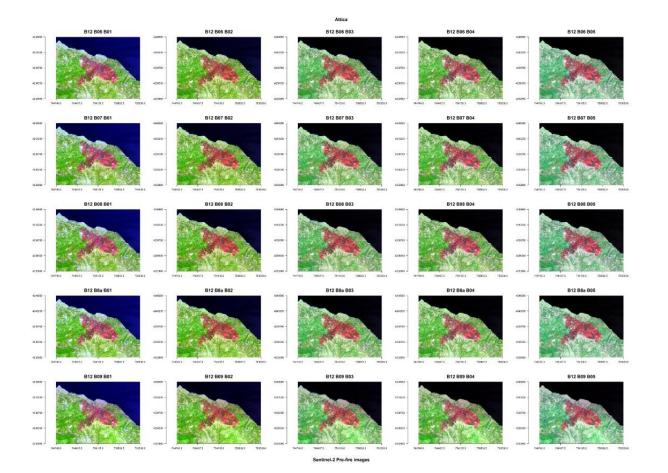


Post-fire sentinel image

Sentinel-2 Pre-fire images

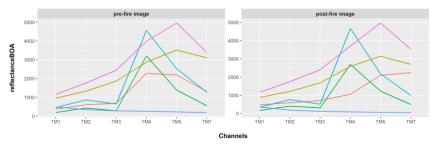
Pre-fire sentinel image

Applying the new set of rules to Sentinel-2 images



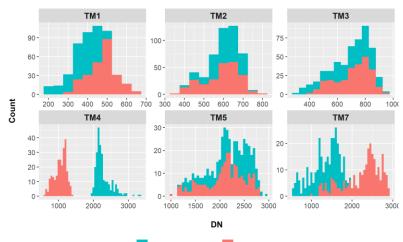
Landsat

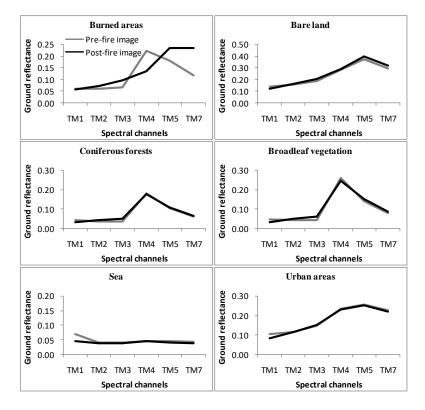
Italy - Landsat





Italy - Landsat

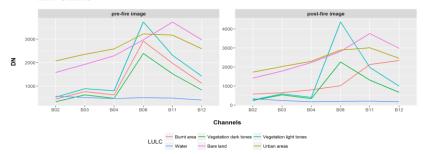




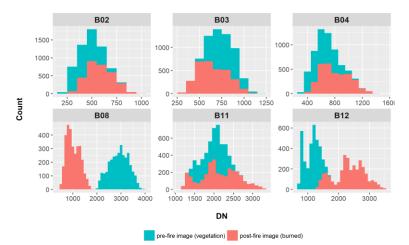
pre-fire image (vegetation) post-fire image (burned)

Sentinel-2

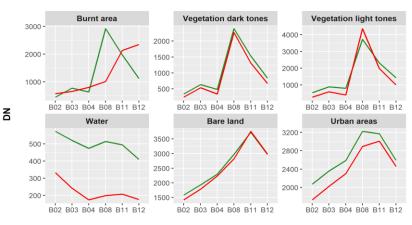
Attica - Sentinel-2



Attica - Sentinel-2



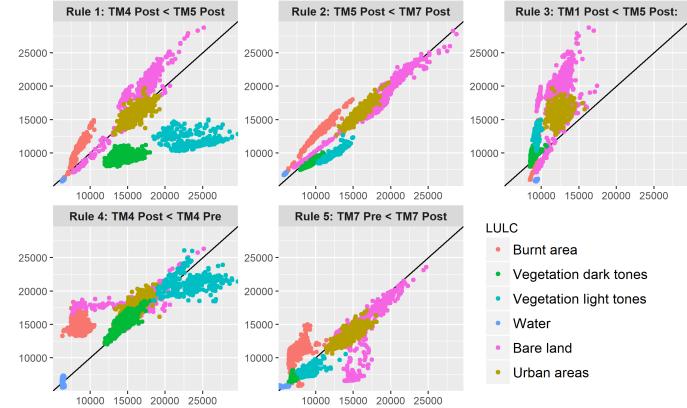
Attica - Sentinel-2



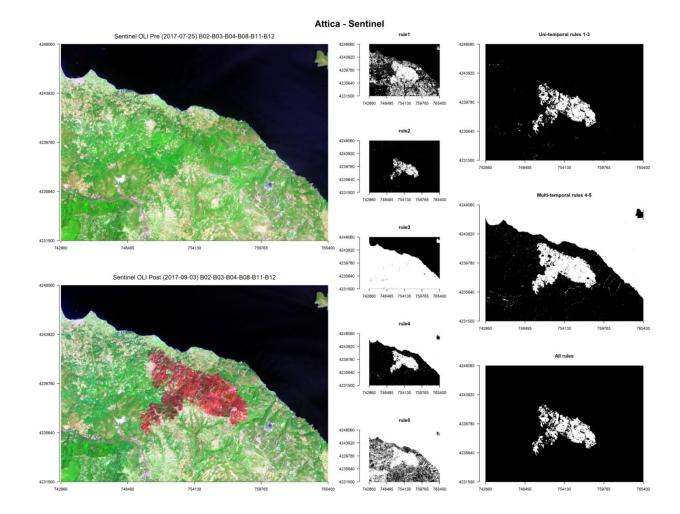
Channels

- pre-fire image - post-fire image

Attica - Landsat



DN



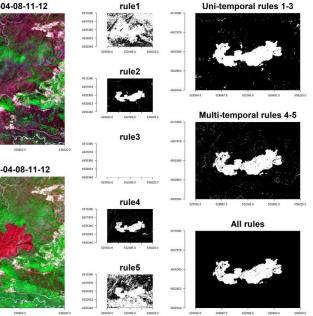
Applying the new set of rules to Sentinel-2 images

Old set of rules

Italy - Sentinel Sentinel Pre (NA) 02-03-04-08-11-12 Uni-temporal rules 1-3 Sentinel Pre (NA) 02-03-04-08-11-12 rule1 4507876 rule2 450536 528967.5 532385.0 535802.5 4505367 5255550.0 539220.0 Multi-temporal rules 4-5 rule3 4500340 4510390 4507878 4505365 Sentinel Post (NA) 02-03-04-08-11-12 Sentinel Post (NA) 02-03-04-08-11-12 4502853 4500342 525550.0 532385.0 538220.0 rule4 535802.5 4507878 All rules 4505365 rule5 1505367 528967.5 532385.0

New set of rules

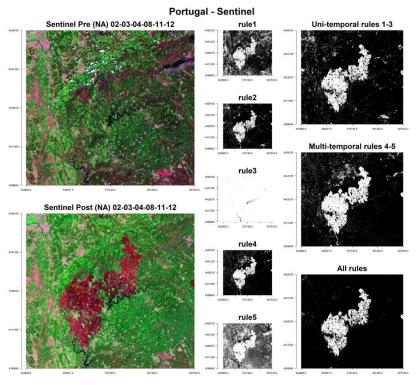
Italy - Sentinel



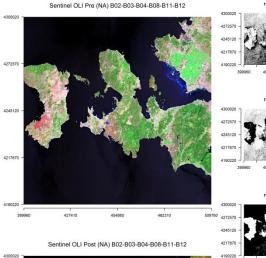
Applying the new set of rules to Sentinel-2 images

Portugal - Sentinel Sentinel Pre (NA) 02-03-04-08-11-12 rule1 Uni-temporal rules 1-3 rule2 Multi-temporal rules 4-5 rule3 Sentinel Post (NA) 02-03-04-08-11-12 rule4 581382.5 \$75195.0 All rules rule5

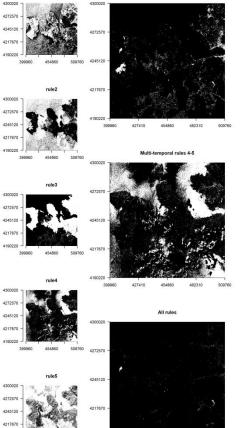
Old set of rules



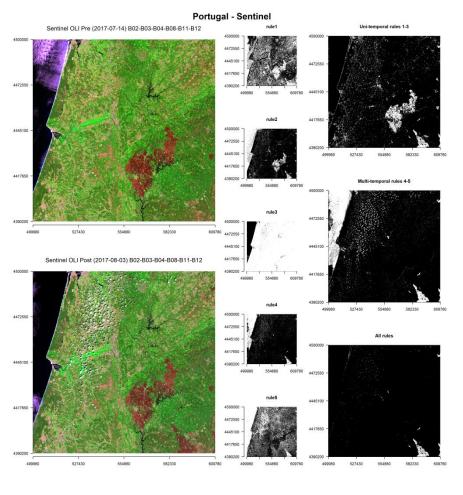








Uni-temporal rules 1-3



Thank you for your attention