FRAMEWORK SERVICE CONTRACT FOR

COPERNICUS EMERGENCY MANAGEMENT SERVICE

RISK & RECOVERY MAPPING

TECHNICAL REPORT

EMSN159: Wildfire on Rhodes island, Greece

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Date	20.11.2023
Issue	2.0

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ACRONYMS

Acronyms	Signification
AD	Applicable Document
AOI	Area of Interest
AU	Authorized User
CEMS	Copernicus Emergency Management Service
EMSN	Emergency Management Service No rush
EMSR	Emergency Management Service Rush
GSD	Ground Sampling Distance
JRC	Joint Research Centre
MMU	Minimum Mapping Unit
NBR	Normalised Burn Ratio
NDVI	Normalised Difference Vegetation Index
ONA	Off Nadir Angle
RD	Reference Documents
RRM	Risk and Recovery Mapping
SRF	Service Request Form
STD	Standard
VHR	Very High Resolution

1 INTRODUCTION

1.1 ACTIVATION DETAILS

COPERNICUS RISK AND RECOVERY MAPPING ACTIVATION	
ACTIVATION DETAILS	
Activation Name	EMSN159: Wildfire on Rhodes island, Greece
Authorized User	General Secretariat for Civil Protection
Date and Time of Activation (UTC)	26.07.2023 14:29
EVENT DETAILS	
Event Type(s)	Wildfire
Location	Rhodes island, Greece
Date and Time of the Event (UTC)	18.07.2023 16:00

Table 1-1: Activation Details

1.2 EVENT DESCRIPTION AND CONTEXT

This CEMS Risk and Recovery Standard activation has been requested following the wildfire event started on 18th July 2023 on Rhodes island, Greece. The fire initially hit an area close to Eleousa, Salakanos and Dimilia villages, but the despite firefighting efforts, the very high temperature and the windy conditions led the fire spreading quickly.

Given the severity of the event, the Authorised User (AU) activated the CEMS Rapid Mapping. Through the EMSR675 activation, fire delineation monitoring products have been delivered (https://rapidmapping.emergency.copernicus.eu/EMSR675/download). Updated information on the status and results of the EMSR675 were also provided through the Situational Report available at https://rapidmapping.emergency.copernicus.eu/EMSR675/reporting.

The CEMS Rapid Mapping analysis confirmed what reported by the news and the AU at the time of the request to activate the CEMS Risk and Recovery Standard: many villages, agricultural and forest areas have been affected from the fire, that had an enormous impact on many touristic and populated areas, so that large scale mass evacuations were ordered and executed.

Figure 1-1 Images of the forest fire that hit the municipality of Rhodes[1].

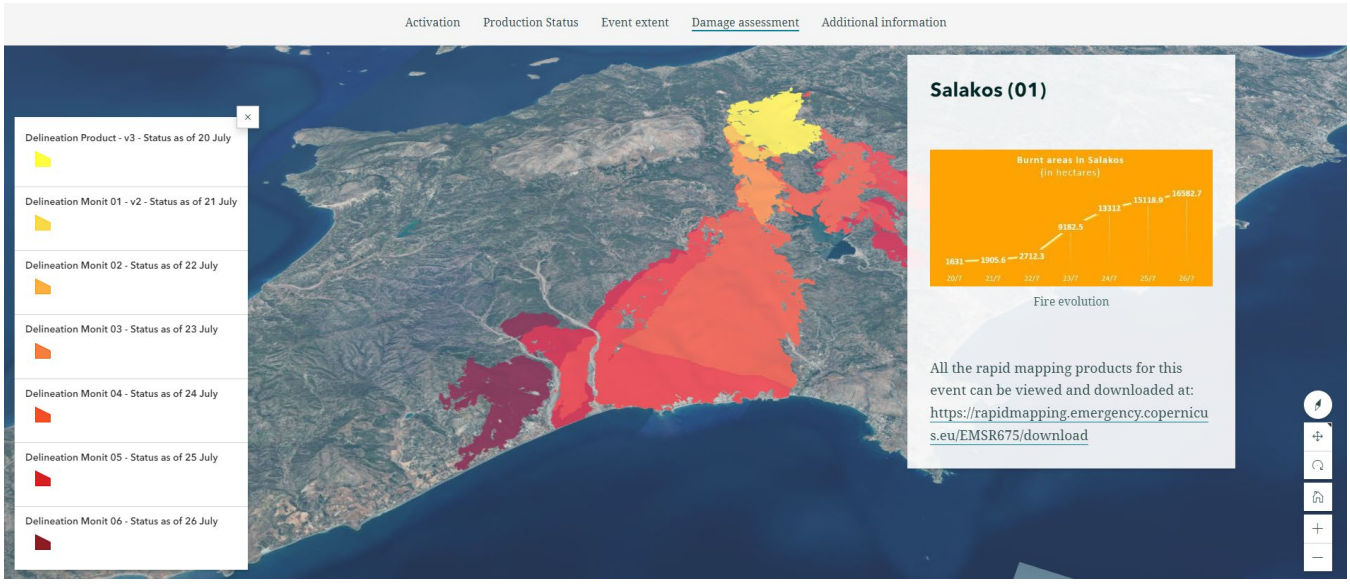

Figure 1-2 EMSR675 Event extent[2], as of 27/7/2023.

[1] Source: Top left: https://www.keeptalkinggreece.com/2023/07/19/rhodes-forest-fire-videos/; Top right and bottom left: https://www.bbc.com/news/uk-england-bristol-66288202; bottom right: https://www.gbnews.com/news/world/rhodes-wildfires-greece-extinction-rebellion-climate-change

[2] https://rapidmapping.emergency.copernicus.eu/EMSR675/reporting

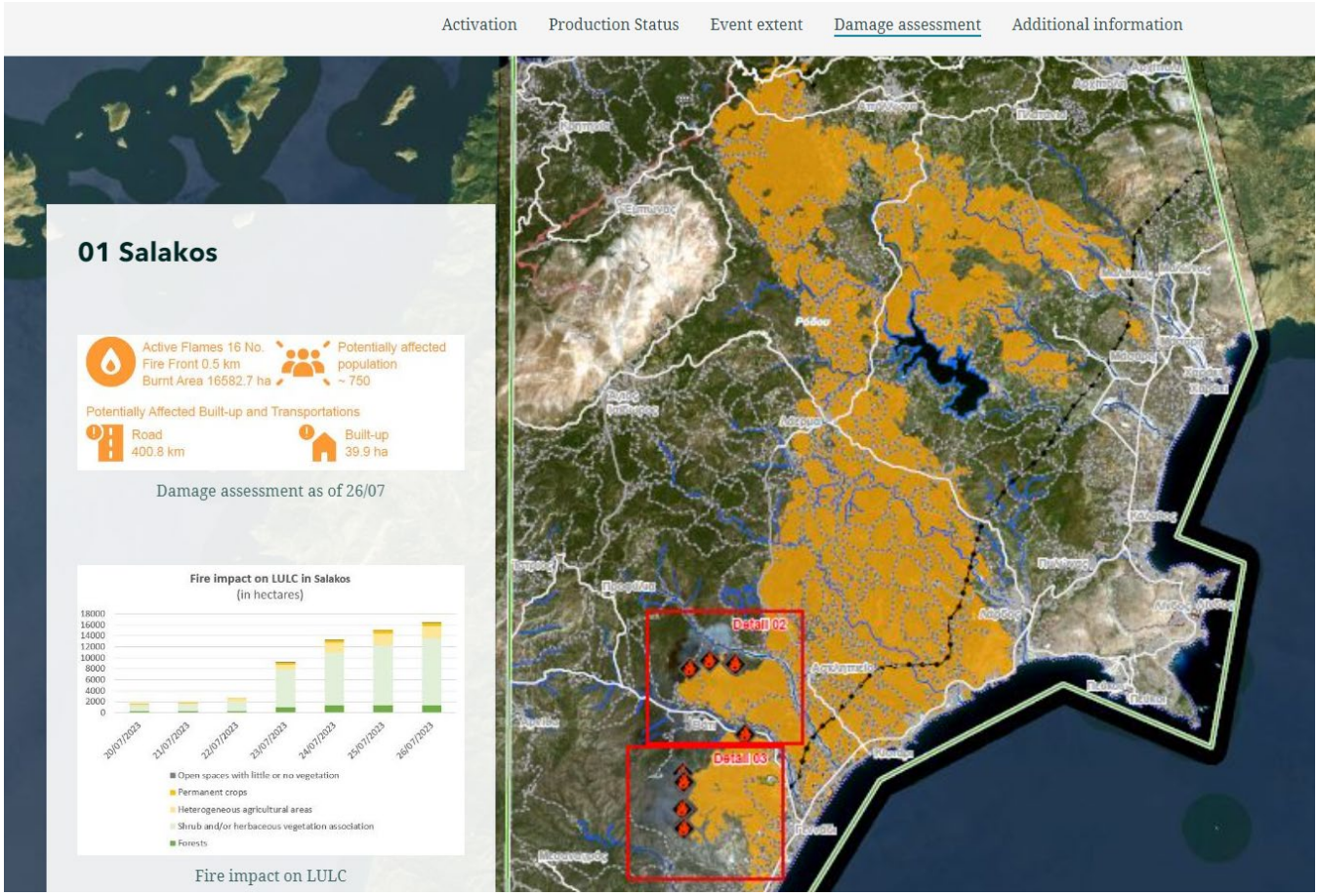

Figure 1-3 Fire impact on LULC, as determined by the wildfire delineation (and monitoring) analysis carried out in EMSR675[2].

The EMSR675 monitoring ended on 29th July, when a GeoEye-1 images showed no active flames in the area, leading the Rapid Mapping service to deliver the Grading product in Figure 1-4.

However, the new version of the Rapid Mapping grading product did not fully satisfy the need of the AU, who was interested in knowing not only the extent and type of affected land cover, but also the severity damage grade. For this reason, the AU activated RRM STD to get the P07-Wildfire delineation and grading product. As reported in the SRF, *Copernicus EMS Mapping products will be used mainly by local authorities (Forest Service, Regional authorities, municipalities) for recovery and restoration planning of the affected area. Furthermore, local authorities are expected to use the mapping products for future flood protection measures, the Greek Agricultural Insurance Organization is expected to use the maps for damage assessment of farming activities, the Ministry of Infrastructure and Transport is expected to use the maps for damage assessment in roads, infrastructure, houses and buildings.*

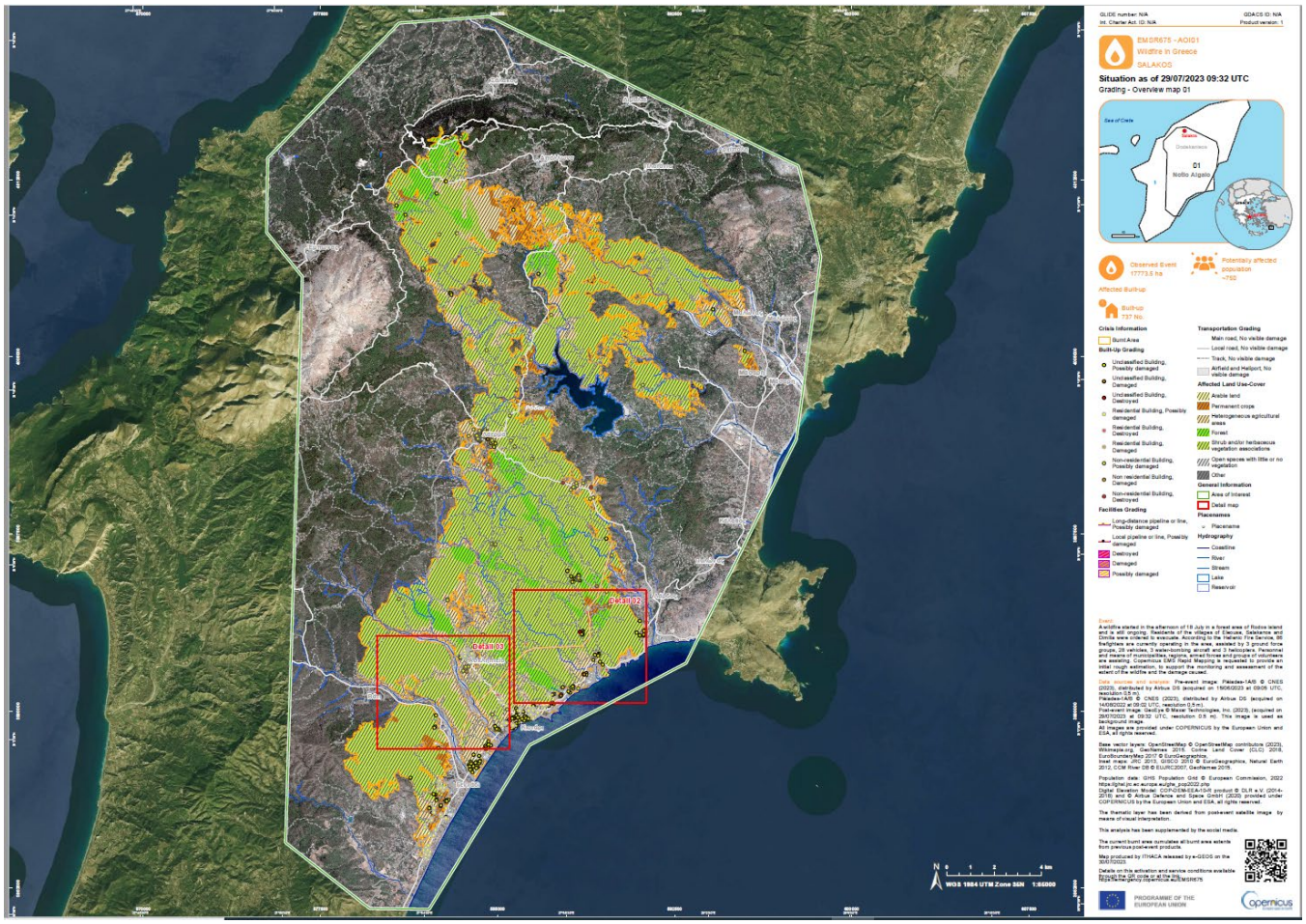

Figure 1-4 EMSR675 Grading product.

Based on the burnt area detected in the final grading product of EMSR675, the AOI has been defined as shown in Figure 1-5, considering the size requirement of the requested P07-Wildfire delineation and grading product:

- **AOI01- ALAERMA** (500 km^2)

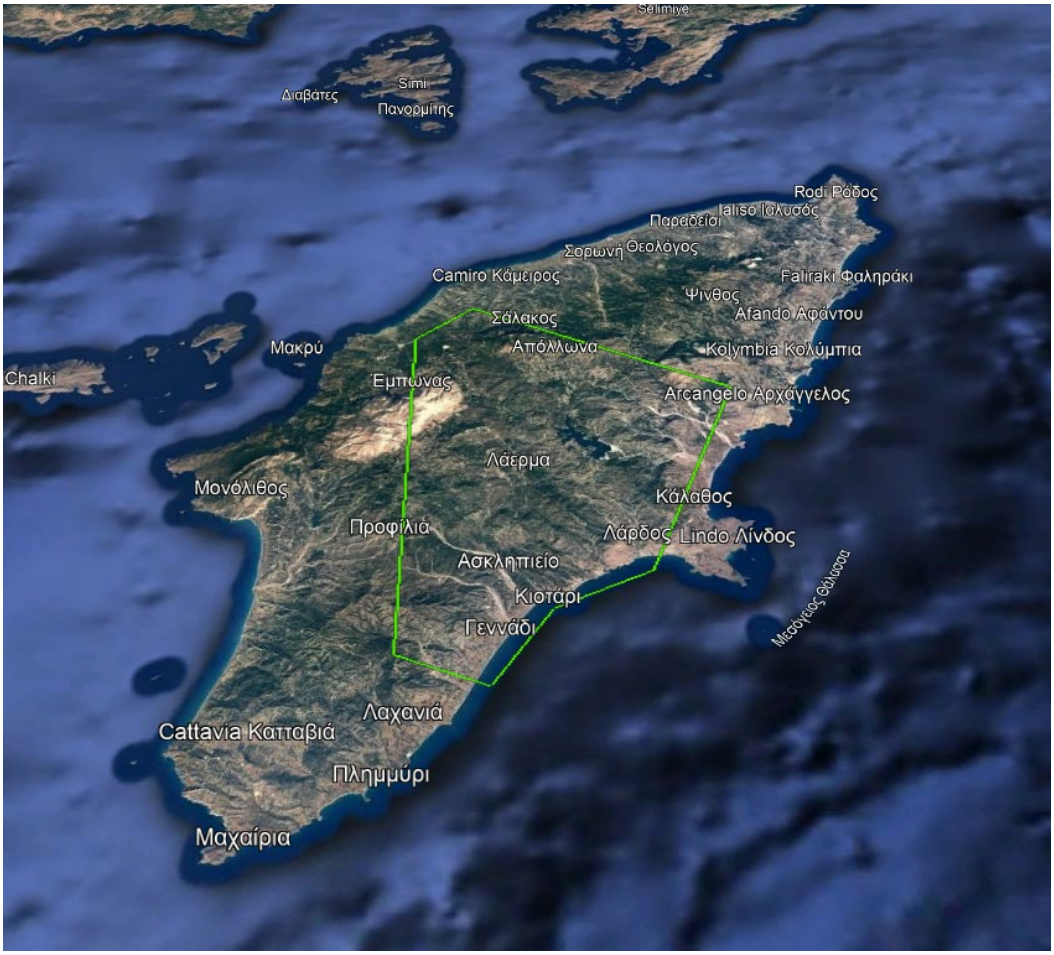

Figure 1-5 AOI01-Aláerma analysed in the framework of EMSN159.

1.3 SERVICE REQUEST

1.3.1 OBJECTIVE

The goal of the activation is to provide wildfire damage delineation and grading product to support local authorities in the recovery and restoration planning of the affected area, as well as for future flood protection measures. Moreover, the Greek Agricultural Insurance Organization is expected to use the maps for damage assessment of farming activities, the Ministry of Infrastructure and Transport is expected to use the maps for damage assessment in roads, infrastructure, houses and buildings.

1.3.2 FEASIBILITY STUDY

The EMSN159 activation was accepted as a result of an accurate feasibility analysis that was carried out to define the requirements necessary to assure the generation of the requested product (see Table 1-2).

REQUESTED PRODUCTS						
Product Code	**Product description**	**Scale**	**Image resolution class/Sensor type**	**Input Data (obligatory)**	**AOI (km^2)**	**Delivery time (days)**
P07	Wildfire delineation and grading	1:25000	VHR, HR	Image data	25-500	5-10

Table 1-2 Technical details for requested standard product.

The feasibility study has led to the commitment of the following product:

- **P07-Wildfire delineation and grading**

FEASIBILITY OF REQUESTED PRODUCTS					
PRODUCT CODE	**PRODUCT DESCRIPTION**	**SCALE**	**AOI(s)**	**Other details**	**Feasible/Not Feasible**
P07	Wildfire delineation and grading	1:25000	AOI01: ALAERMA (500 km^2)	N/A	✓

Table 1-3 Technical feasibility statement for the EMSN159 Activation

1.3.3 PRODUCTS DESCRIPTION

The product generated within this activation is described in Table 1-4.

	AOI	Product description
P07	AOI01	The **wildfire delineation and grading** product shows the delineation of the burnt area and the associated level of damage as derived from post-event optical VHR images. The P07 product shows that the majority of the analyzed areas have been assessed as high and moderate damage by analyzing the variation of the NDVI.

Table 1-4 Products description

The final delivery includes the products reported in Table 1-5.

Product Name		AOI	Description	Type	Scale	Num.
RRM OVERVIEW MAP	1	AOI01	P07-Wildfire delineation and grading	Overview Map	1:70000	1
GDB	2	-	Geodatabase with results	GDB	-	1
Technical Specifications FWC	3	AOI01	.geojson files of: - AOI - P07 Delineation product - P07 Grading product	Vector	1:25000	3
	4	-	Symbology used for delivered vectors	.lyr, .sld files	-	4
	5	-	Consequence tables of: - P07 Wildfire delineation and grading	.xlsx files	-	1
	6	-	Metadata for the GDB and all the feature classes within the gdb and map delivered	.xml files	-	7

Product Name		AOI	Description	Type	Scale	Num.
	7	-	Flyer	Report	-	1
	8	-	Factsheet	Report	-	1
	9	-	Final Report	Report	-	1

Table 1-5 Deliverables description

2 INPUT DATA

Input data for EMSN159 mostly consist in pre and post-event VHR optical images used for the P07-Wildfire delineation and grading product. In addition, OSM reference data and (affected) settlements released with EMSR675 Grading product, were used for the map representation.

2.1 EO DATA

Data type	Sensor	Acquisition date and time (UTC)	GSD (m)	Off-nadir angle (°)	Cloud cover (%)	RRM STD Products
PRE-EVENT SATELLITE IMAGERY	PlanetScope	17/07/2023 08:34	3.0	4.9	0	P07
	PlanetScope	18/07/2023 08:02	3.0	4.4	0	P07
POST-EVENT SATELLITE IMAGERY	PlanetScope	31/07/2023 08:36	3.0	1.3	0	P07

Table 2-1 EO Data for EMSN159 P07 product

Data type	Sensor	Acquisition date (or interval)	Request submission date and time (UTC)	Reception date and time (UTC)
PRE-EVENT SATELLITE IMAGERY	PlanetScope	17/07/2023 08:34	02.08.2023 09:15	03.08.2023 11:05
	PlanetScope	18/07/2023 08:02	03.08.2023 09:33	03.08.2023 11:05
PRE-EVENT SATELLITE IMAGERY	PlanetScope	31/07/2023 08:36	02.08.2023 09:15	03.08.2023 12:05

Table 2-2 EMSN159 Imagery procurement details

2.2 OTHER INPUT AND ANCILLARY DATA

Data source	Provider	Format	Availability	Use
OSM	OSM	Vector	www.osm.org	Transportation, placename, facilities and hydrology layers as reference data. Thematic layers for map production

Data source	Provider	Format	Availability	Use
Buildings	Buildings: Copernicus EMSR675 Grading Product	Vector	https://rapidmapping.emergency.copernicus.eu/EMSR675/download	Affected buildings reported in the EMSR675 product

Table 2-3 Input and ancillary data for EMSN159 products

3 METHODOLOGY

3.1 P07 – WILDFIRE DELINEATION AND GRADING

The P07- Wildfire delineation and grading products provide an assessment of the event's impact, its spatial distribution, and extent. The product covers any event type related to wildfire and provides generic information about the affected land. The product is directly derived from the image data, acquired as soon as possible after the emergency event, and consists of the collection of burnt areas together with damage grade information.
Figure 3-1 below shows an example proving that given the large spectral difference between vegetated and burnt areas, the spectral image processing approach is applicable in mapping burnt areas.

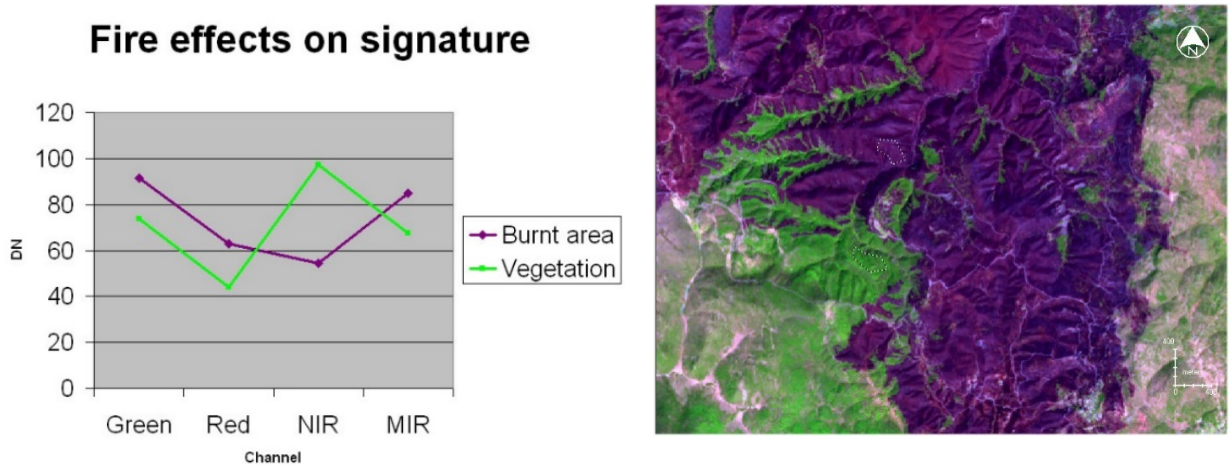

Figure 3-1: Digital number counts used to compare healthy vegetation (green) with a burnt area (purple) within the same image. One can note a relative increase in the visible and Short Wave InfraRed (SWIR) channels and dramatic decrease in values within the Near Infrared channel. The values are derived from a SPOT 5 image acquired on the 02 September 2007, ©CNES 2007, distribution AIRBUS DS, all rights reserved.

Despite this approach being suitable in most cases, it will never be perfect in areas of sparse vegetation, and unfortunately other areas can get mixed up. To obtain the most accurate results a manual validation phase is essential in the P07 production workflow.

3.1.1 WILDFIRE DELINEATION

The wildfire delineation product is based on change detection between dates prior and after the fire event. The first step is to select two sets of images relevant for the burnt area detection. Images should be acquired as close as possible to the event and to each other, to ensure a highly discriminable burnt scar and similar vegetation states in its surroundings for both dates. In the framework of the EMSN159 activation, the *Normalised Burn Ratio* (NBR) could not be calculated as the PlanetScope datasets used for production do not have a SWIR channel.
Objects under the Minimum Mapping Unit (MMU) equal to 0.25 ha were removed.

3.1.2 WILDFIRE GRADING

The wildfire grading is computed using the wildfire delineation previously mapped and the dNDVI layer. The procedure without SWIR channels has been applied in this activation.

The *Normalized Difference Vegetation Index* (NDVI) represents the vegetation health state and have strong capability in extracting wildfires burned areas and impacts. The NDVI is calculated as:

$$NDVI = \frac{NIR - RED}{NIR + RED}$$

Once the index is calculated for the reference and crisis images, change detection is applied by subtracting the crisis indices layers from their respective reference layer, resulting in a dNDVI layer.

The damage grades will be specific to a given event, being presented by four classes namely:

- Destroyed
- Highly Damaged
- Moderately Damaged
- Negligible to Slight Damaged.

The method is straightforward and widely used and well described in the IWG-SEM guidelines. The dNDVI is calculated and classified according to the adapted IWG-SEM classes, as illustrated by the table below. As four classes are requested in the standard P07 product, the *Moderate severity* class of the IWG SEM classification is split into two CEMS RRM classes, *Moderately damaged* and *Highly damaged.*
Following feedback from the Authorized User the thresholds were modified to better fit the situation on site (dNDVI on site).

IWG-SEM classes	EMS RRM classes		dNDVI	dNDVI on site
Low severity	Negligible to slight damage		dNDVI <= 0.3	dNDVI <= 0.12
Moderate severity	Moderately damaged		0.3 > dNDVI <= 0.41	0.12> dNDVI <= 0.27
	Highly damaged		0.41 > dNDVI <= 0.55	0.27 > dNDVI <= 0.44
High severity	Destroyed		dNDVI > 0.55	dNDVI > 0.44

Table 3-1 Severity classes correspondence table between IWG-SEM and CEMS RRM

4 RESULTS

4.1 P07 – WILDFIRE DELINEATION AND GRADING

According to the information provided by the EMSR675, the forest fire that hit the area of Aláerma affected many villages, agricultural and forest areas. The analysis performed in the framework of this EMSN159 activation shows that 17629,1 ha were burnt and most of the area has been moderately damaged.

The fire grading based on dNDVI on site thresholding is shown in Table 4-1 and in Figure 4-1.

	Unit of measurement	Destroyed	High damage	Moderate damage	Negligible to slight damage	Total affected
Burnt area	ha	1337,1	7856,4	6143,8	2291,5	17628,8

Table 4-1 Break down of affected areas by fire severity grading for AOI01-ALAERMA

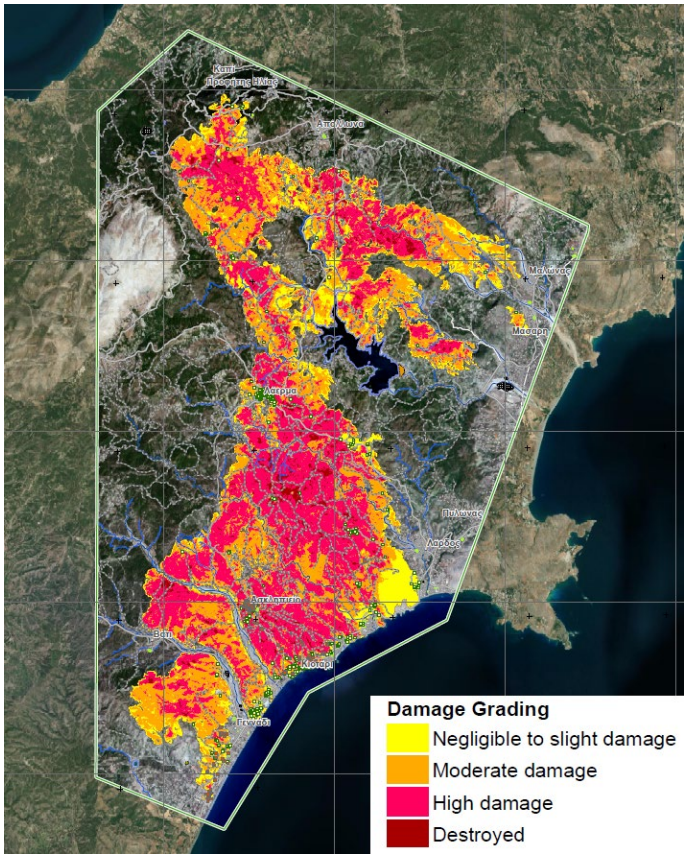

Figure 4-1 P07-Wildfire delineation and grading product in AOI01-ALAERMA

5 INTERNAL QUALITY CONTROL

5.1 P07 – WILDFIRE DELINEATION AND GRADING

5.1.1 THEMATIC ACCURACY

Thematic validation is performed to assess the thematic quality of P07 product. The wildfire delineation consists of a layer representing 2 classes: burnt and unburnt areas. Congalton, Russell G. and Kass Green (2002)[3] suggest that in the case of a change/no change map, a binomial class distribution is appropriate for assessing the sample size. An example is also presented; for a 90% accuracy and a confidence level of 95%, a sample size of 298 is required. The thematic accuracy required for P07 is 85%, so a sample size of 300 allows to ensure to reach this accuracy and even to be on the safe side.

The same authors proposed a method for increasing the number of samples in the areas surrounding the burned scar. The number of samples are dispersed as shown in Table 5-1.

Strata	Percentage of total samples	Number of samples
Burnt area	40	120
Direct surroundings	30	90
Rest of the AOI	30	90

Table 5-1: P07 - Sampling strategy

The sampling strategy is stratified and random. The “burnt area” stratum is self-explanatory. The “direct surrounding” stratum corresponds to areas in contact with the burnt area where confusions in the fire delineation are expected to be probable. This area is defined by a buffer of 200m around the burnt area. The “rest of the AOI” stratum is also self-explanatory.

For each sample point, the correctness of the classification was assessed manually on the same image used for production by an operator that was not involved in the previous steps of the production. The accuracy of the delineation product is assessed through Producer’s, User’s, and finally Overall accuracies. The Overall accuracy of the product must be over 85%. The result of this validation step is reported below.

[3] Congalton, Russell G., and Kass Green. *Assessing the accuracy of remotely sensed data: principles and practices*. CRC press, 2002.

		Validation assessment			
		Unburnt	Burnt	Total	User's Accuracy
Damage assessment	Unburnt	112	8	120	93,3%
	Burnt	5	175	180	97,2%
	Total	117	183	300	
	Producer's Accuracy	95,7%	95,6%		OA = 95,7%

Table 5-2 P07-Wildfire delineation and grading validation results in AOI01-ALAERMA

5.1.2 GEOMETRIC POSITIONAL ACCURACY

The positional accuracy of P07 product is dependent on the input satellite images positional accuracies. All images were delivered already orthorectified, so no positional accuracy was conducted.